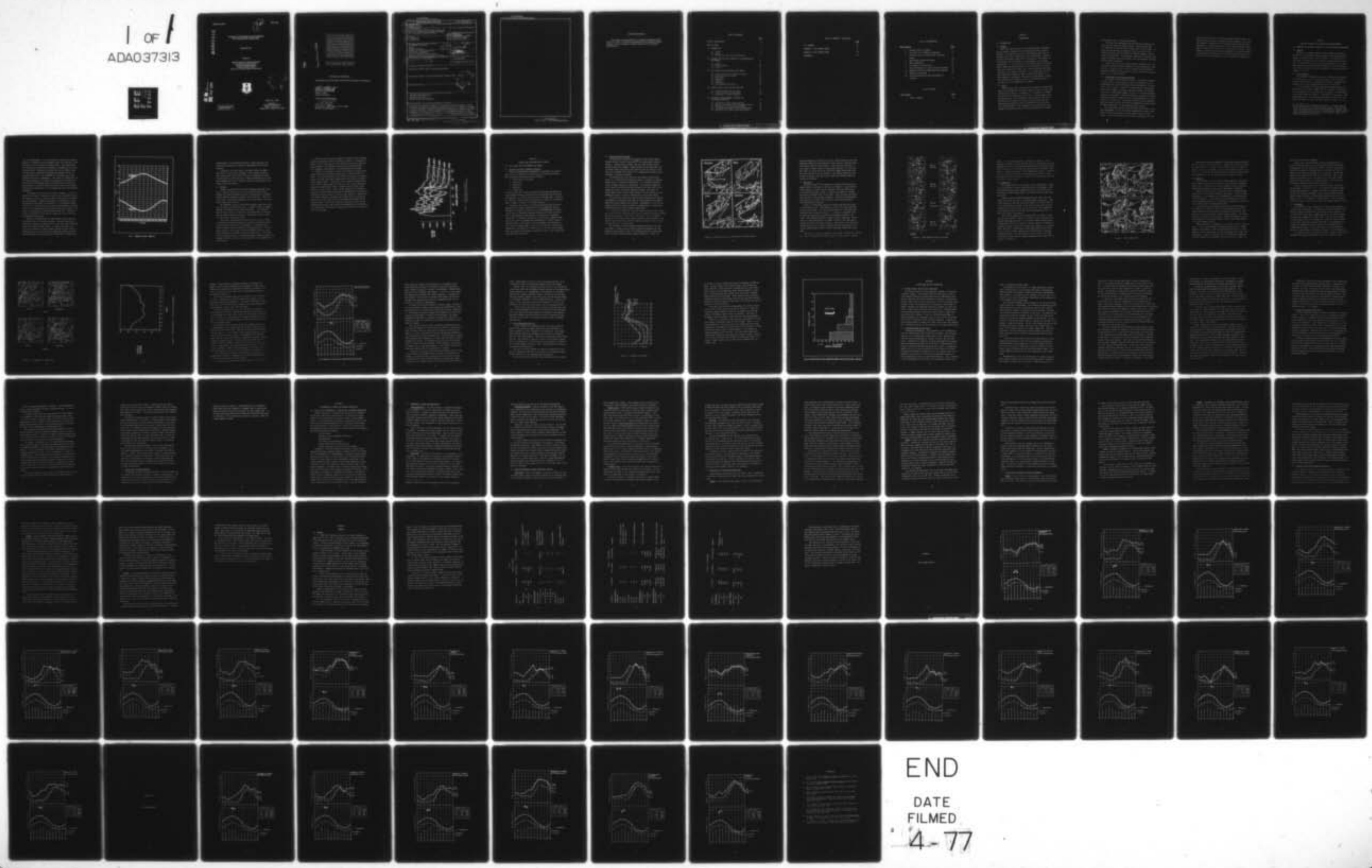
AD-A037 313 MITRE CORP BEDFORD MASS F/G 4/2
EFFECTS OF WEATHER ON NATO/WARSAW PACT AIR/GROUND OPERATIONS.(U)
JAN 77 V J STAKUTIS F19628-76-C-0001
UNCLASSIFIED MTR-3300 ESD-TR-76-292 NL

1 OF 1
ADA037313



END
DATE
FILMED
4-77

ESD-TR-76-292

MTR-3300

FG

12

ADA037313

EFFECTS OF WEATHER ON NATO/WARSAW PACT AIR/GROUND OPERATIONS

JANUARY 1977

Prepared for

DIRECTORATE OF INTELLIGENCE
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
Hanscom Air Force Base, Bedford, Massachusetts

Project No. 7900

Prepared by
THE MITRE CORPORATION
Bedford, Massachusetts
Contract No. F19628-76-C-0001

Approved for public release;
distribution unlimited.

REVIEW AND APPROVAL

This technical report has been reviewed and is approved for publication.

ELIAS E. SCHWARTZ
Major, USAF
Project Engineer

FOR THE COMMANDER

CHARLES C. VOGLER, Lt Col, USAF
Director of Intelligence

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

19 REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
18 1. REPORT NUMBER ESD-TR-76-292	2. GOVT ACCESSION NO	3. RECIPIENT'S CATALOG NUMBER
6 4. TITLE (and Subtitle) EFFECTS OF WEATHER ON NATO/WARSAW PACT AIR/GROUND OPERATIONS.		5. TYPE OF REPORT & PERIOD COVERED
		14 6. PERFORMING ORG. REPORT NUMBER MTR-3300
10 7. AUTHOR(s) V. J. Stakutis		15 8. CONTRACT OR GRANT NUMBER(s) F19628-76-C-0001
9. PERFORMING ORGANIZATION NAME AND ADDRESS The MITRE Corporation Box 208 Bedford, MA 01730 12 90p.		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Project No. 7900
11. CONTROLLING OFFICE NAME AND ADDRESS Directorate of Intelligence Electronic Systems Division, AFSC1 Hanscom Air Force Base, Bedford, MA 01731		11 12. REPORT DATE JAN[redacted]977
		13. NUMBER OF PAGES 94
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) 9 Technical rept.,		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

AIR/GROUND OPERATIONS
MILITARY WEATHER
OPERATIONAL ENVIRONMENT

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This paper was prepared in support of a Project 7900 long-term analysis to better understand and define the integrated air/ground threat in central Europe. The paper provides a descriptive summary of environmental conditions in central Europe whose probability for recurrence in calendar time can be predicted broadly from a long statistical history of occurrence. The effect of the conditions on military operations is assessed in terms of the opportunities it provides and/or the limitations it imposes.

235 050

ACKNOWLEDGMENTS

This report has been prepared by The MITRE Corporation under Project No. 7900. The contract is sponsored by the Electronic Systems Division, Air Force Systems Command, Hanscom Air Force Base, Massachusetts.

TABLE OF CONTENTS

		Page
LIST OF ILLUSTRATIONS		5
LIST OF TABLES		5
1.0	INTRODUCTION	7
1.1	Purpose	7
1.2	Scope	7
1.3	Climatology for Military Operations	8
2.0	BACKDROP FOR MILITARY PLANNING IN A METEOROLOGICAL ENVIRONMENT	10
2.1	General	10
2.2	Solar Elevation	10
2.3	Terrain	13
3.0	THE CLIMATE FOR NATO/WARSAW PACT FORCES	16
3.1	Selection and Fit of Weather Features	16
3.2	Storm Tracks Over Europe	17
3.3	Wind Flow	19
3.4	Temperature	21
3.5	Moisture	22
3.6	Cloudiness	24
3.7	Cloud Dimensions/Vertical	30
4.0	GERMAN CLIMATE AND MILITARY OPERATIONS	34
4.1	A Weather Sensitive Air Power	34
4.2	Terrain Sensitive Ground Force	38
4.3	Operations -- Weather Imbalance	40
5.0	APPLYING THE ENVIRONMENT TO WARSAW PACT AIR/GROUND OPERATIONS	42
5.1	Capability to Mount CBW Operations	43
5.2	Physical Movement of Heavy Equipment and Men	44
5.3	Capability to Perform Reconnaissance	46
5.4	Air Operations Support of Frontal Movements	49
5.5	Capability for Visual Target Acquisition	52

TABLE OF CONTENTS (Concluded)

	Page
6.0 SUMMARY	56
APPENDIX I WEST GERMAN CHARTS	63
APPENDIX II EAST GERMAN CHARTS	83
REFERENCES	90

LIST OF ILLUSTRATIONS

Figure Number		Page
1	Daylight Hours in Germany	12
2	Pact View of W. Germany's Topography	15
3	Principal Tracks of Depressions in Western Europe	18
4	Mean Monthly Winds Over Europe	20
5	Mean Temperature	22
6	% Frequency of Cloud Cover	25
7	Percent Frequency of Cloud Cover Over Germany	26
8	Monthly Cloud Cover/Temperature/Precipitation	28
9	Hamburg's Cloudiness	31
10	Cloud Amounts Within Specified Ranges of Altitude	33

LIST OF TABLES

Table Number		Page
I	Tabular Summary	58

SECTION 1

INTRODUCTION

1.0 INTRODUCTION

1.1 Purpose

This paper describes some of the meteorological conditions of the regions contiguous to the border between West and East Germany. The ultimate purpose is to demonstrate that this environment must enter significantly into the planning, execution, and scope of military operations in this region. The subject to be treated is not the weather of precise daily or long range forecasting. It is more nearly a descriptive summary of environmental conditions whose probability for recurrence in calendar time can be predicted broadly from a long statistical history of occurrence. Such weather averages, viz., climatology, will almost inexorably overtake military air/ground operations -- to their benefit or detriment. The effect of such weather on military operations is assessed in terms of the opportunities it provides and/or the limitations it imposes.

1.2 Scope

The discussion that follows will be bounded in several ways. First, the NATO/Warsaw Pact border region is much too large to be treated here in detail. Fortunately, it is possible to assume the terrain to be generally of two types, a plains region and a mountainous one. The environmental conditions will then be descriptive for this division. It can also be assumed that the meteorological parameters will be applicable out to 100 km or more from the border. This assumption is consistent with the breadth of weather patterns overrunning Europe but does ignore

perturbations due to local peculiarities.

Secondly, the environment will be discussed frequently in terms of the winter and summer seasons. Meteorological data are tabulated in monthly periods which serve to show trends. In this case the monthly meteorological data and those of the grosser seasonal division exhibit only subtle changes or define transitional periods. The important comparison for military purposes in Central Europe and Germany is the environmental contrast between summer and winter.

Third, some selection of meteorological parameters has been made based on what has been presumed to be most important to support or to interfere with a broad air/ground frontal movement. Emphasis, thereby, has been placed on cloud cover and on precipitation as it affects terrain.

1.3 Climatology for Military Operations

An estimate of the probable effects or influence of weather on short bursts or long thrusts of military operations in the NATO/Warsaw Pact region must begin with an examination of climatology of the region. It has to be understood that climatology deals with averages of weather conditions obtained from observations over a considerable number of years. The derived probabilities do not guarantee a rigidly mechanical reproduction of meteorological conditions either in time or simultaneously over every portion of a broad area. Variations from the average conditions must be expected over the most nearly homogeneous terrain because of modest differences in topography and other factors.

The topography along the long West/East German border is far from homogeneous. In the rolling and mountainous terrain of the South, the climatology may vary from mountain tops to valley slopes. In the flat Northern plain region, adjustments for wind

and cloud cover may have to be made depending on which side of a river, such as the Elbe, the meteorological parameter is of critical interest. Compensations for average weather conditions will always have to be made on the basis of the current weather system over the theater of operations or in particular localities. Nevertheless, if military action can be deferred to a season favoring its execution, the likelihood of a desired weather condition turning up is fairly well defined by the climatological probability.

SECTION 2

MILITARY PLANNING IN A METEOROLOGICAL ENVIRONMENT

2.0 BACKDROP FOR MILITARY PLANNING IN A METEOROLOGICAL ENVIRONMENT

2.1 General

Weather is a complex product of many elements, principally the sun for its beginnings and development and, secondarily, geographical features as they alter its modes. Both these factors also enter inevitably into the planning of modern military operations. Because they become so involved with weather, it is felt that some attention should be given explicitly to solar elevation and terrain for Central Germany preliminary to taking up the environment of the area.

2.2 Solar Elevation

The available illumination (and total energy) at the surface of the earth is a function of solar elevation. The coursing of the sun, with respect to a geographical location, determines the length of day or the illuminated period at that location.

At the latitude of northern Germany the maximum solar noon elevation is about 60° in summer and 13° in winter. Extraterrestrial illumination at solar noon over the equator is extrapolated to be about 11,000 foot-candles*. Consequently, the range of maximum illumination at 54° north latitude runs from about 7500 foot-candles in summer to about 2500 foot-candles in winter - at the

*A foot-candle is the illumination falling on a surface one-foot square at one foot from a unit standard candle. Traditionally, the specifications for visibility and photographic exposure make use of the psycho-physical units of illumination. Modern electro-optical sensitometry deals more with the absolute values of irradiation measured in watts/m^2.

top of the atmosphere. If a 25% reduction is applied for attenuation by a relatively clean atmosphere, more than sufficient illumination is still available at ground levels. The normal human eye requires about 100-150 foot-candles of illumination for close tolerance work. Problems with seeing will arise, however, with the lower solar elevations of morning and evening and with increased attenuation in the atmosphere as pollutants and clouds interfere with solar transmission. The levels of illumination can then become marginal for seeing from moving vehicles deeper into the day from the beginning and the end points of the solar day. Reconnaissance, especially before and after combat, will require decisions and capabilities for the optimum low light level imagery obtainable.

The length of the solar day is shown in Figure 1, a plot by month of the times of sunrise and sunset at the latitude of Berlin. The important feature is the short dawn to dusk 8 hour day during the winter months. Despite the advances of technology in radar and infrared sensitometry the character of a coordinated advance in mass over a wide area will still place great demands on visible deteccion for maneuvering, moving target selection, artillery fire control, reconnaissance, air-to-ground strikes, etc. Effective broad scale military action must be compressed at this time into an abbreviated working day.

Extensive cloudiness will be superimposed on this seasonal, latitudinal decay of available daylight. Overcast conditions of winter will extend the natural period of low light levels reducing further the usable daylight hours. A continuous, dense cloud cover will attenuate the usual maximum seasonal daytime levels of illumination by at least an order of magnitude thereby reducing scene brightnesses and target contrasts important to photographic

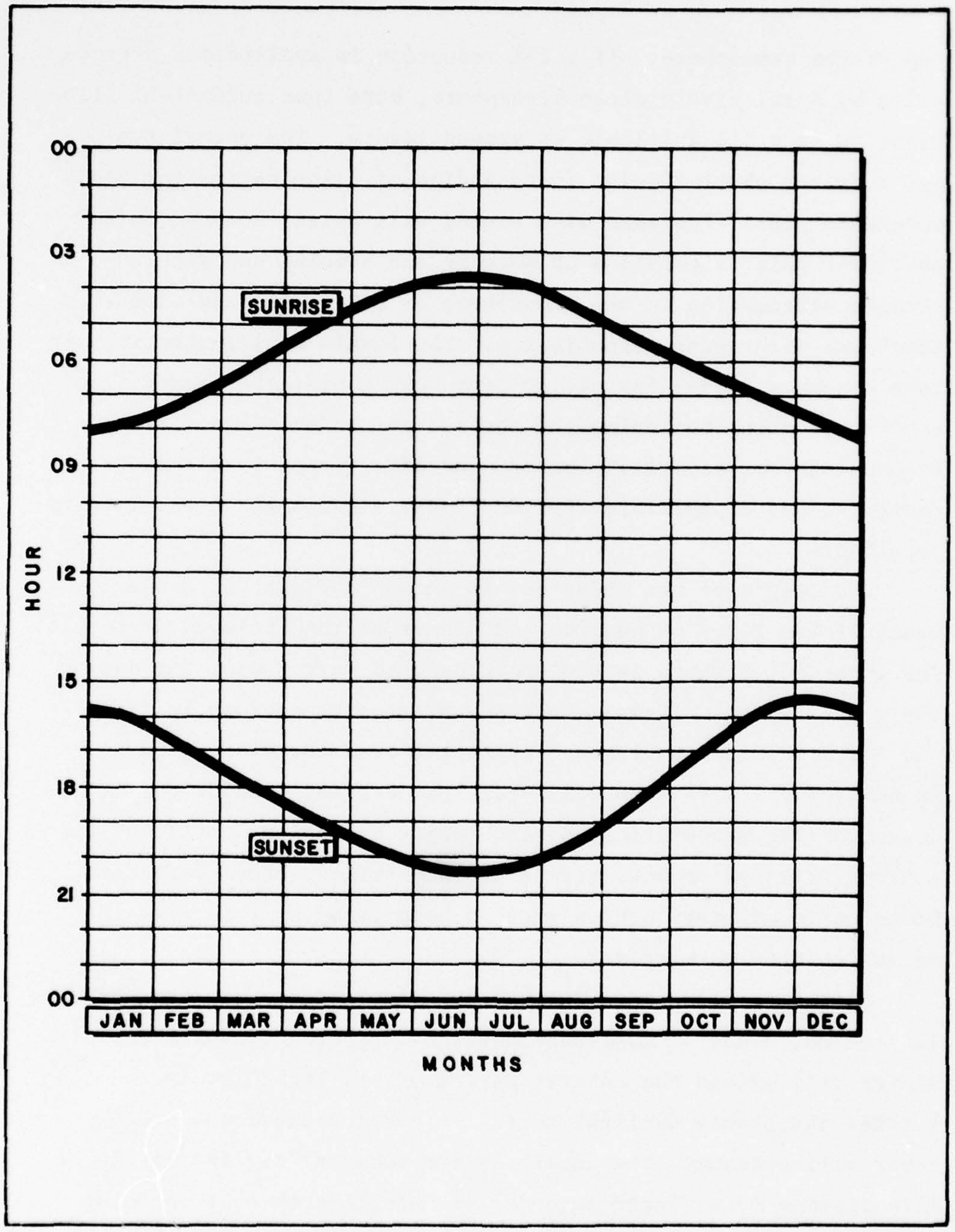


Fig. 1. Daytime Limits (Berlin)

reconnaissance, air-to-ground detection, target spotting, and restricting operational visibility ranges wherever they may be required.

Conversely, the full range of daylight during the summer months will be more nearly available. The twilight periods at this latitude will allow nearly 18 hours of daylight with much less obscuration from cloud cover. Higher probabilities of clear and scattered skies will, therefore, expose ground operations for longer unrelieved periods.

2.3 Terrain

Germany is dominated by two great European topographic features. Northern Germany is part of the broad Eurasian plain. Central and Southern Germany occupies a large portion of Europe's central uplands, gradually rising to the Alpine Wall. These features permit a relatively unimpeded flow of maritime air over the whole region from the west.

The immediate coasts of the North and Baltic Seas show extensive sand areas with shifting dunes. A number of barrier beaches, lagoons, and submarine bars impede navigation. This brackish, shallow water freezes at relatively high temperature so that the port of Lubeck frequently requires ice-breakers to keep it open for ship traffic during the winter.

The plain, sloping gently up from the beach line, is simple in structure and surface features. Recurrent continental glaciation developed several lines of moraines -- an accumulation of surface material from the deposits of melting glaciers. To cross these moraines, rivers were forced into east-west flows so that their patterns have a number of definite elbow turns. The spread of this glaciated surface is dotted with lakes, extensive heath, and marshes relieved at times by rolling mounds of a few hundred feet in elevation.

Farther south, the interior begins to break up into a complex region of mountains, valleys, plateaus, and basins Eventually it merges into an outer ring of older highlands from the central plateau of France to the Bohemian Plateau of Czechoslovakia which rises somewhat precipitously at this NATO/Warsaw Pact border.

Figure 2 is an attempt to depict the character of this topography, normalized from north to south out to 60 miles from the border. The narrow northern plain region gives way to an irregular pattern of peaks and valley fissures which would seem to impede a broad frontal advance. During the winter months the higher peaks (up to 4000') trigger deep snow falls on their crests; during the summer the unpredictable spill of thunderstorms on their slopes would be of some concern. Under cloudy conditions the irregular pattern of valleys and hills becomes an impediment to aerial reconnaissance forcing tortuous, twisting flight patterns. Hidden with this jumble, however, lie basins and plateau areas of varying dimensions that will modify locally the ambient environment of the general region. This overly compressed depiction of the terrain nevertheless provides some inkling that adjustments for meteorological and military flow will be required from the north to south of 52^{o} north latitude.

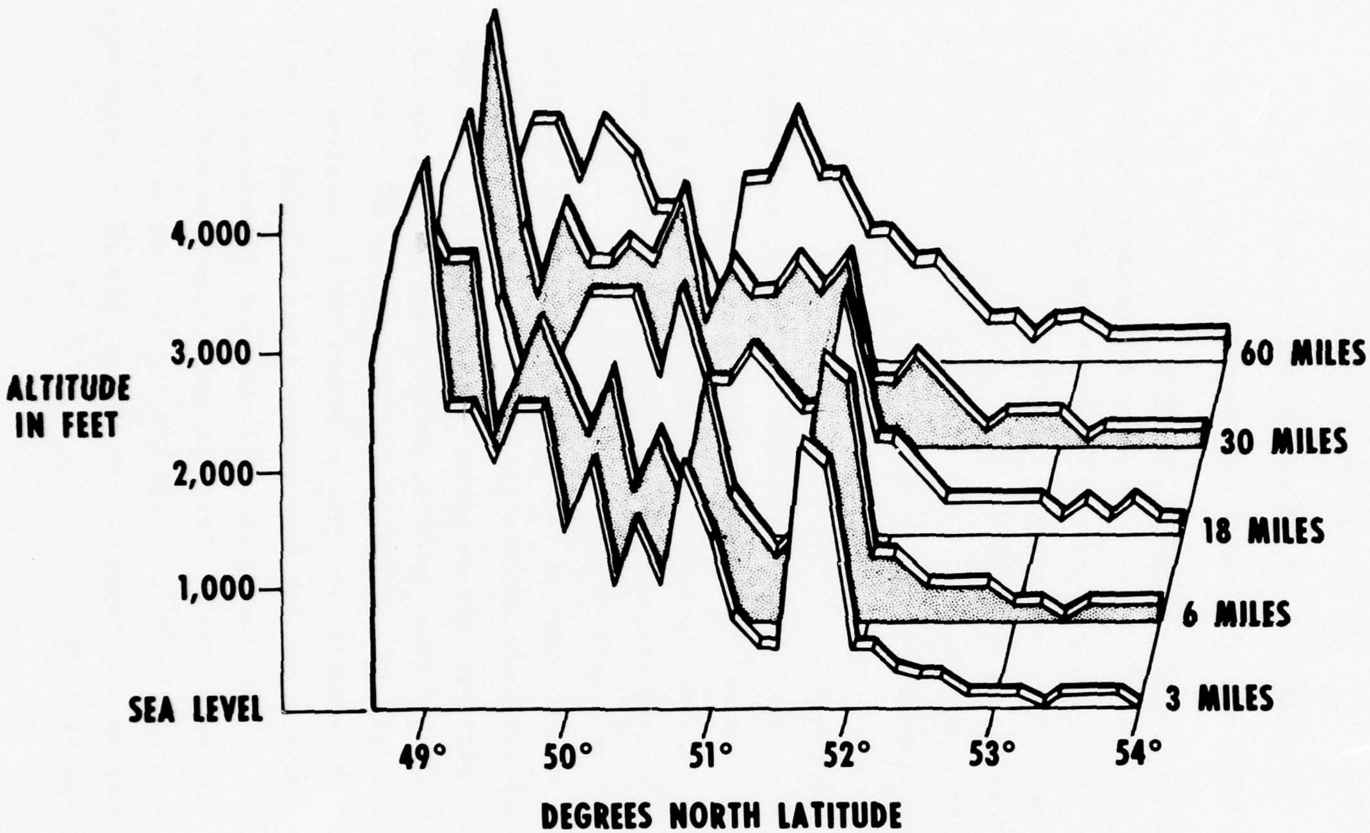


Figure 2. West Germany Topography
(Viewed West From The Border)

SECTION 3

CLIMATE FOR NATO/WARSAW PACT FORCES

3.0 THE CLIMATE FOR NATO/WARSAW PACT FORCES

3.1 Selection and Fit of Weather Features

Among the meteorological parameters or phenomena that should enter into the planning of operations across the German borders, the following deserve some special attention:

1. Storm tracks over Europe
2. Wind flow
3. Temperature
4. Moisture
5. Cloud cover

It will be seen that there are seasonal and diurnal differences in these weather features from which military maneuverings could gain an advantage. A favoring period, however, may span only a fraction of a day for a swift thrust; several days to a week for an extended push; a season to support a prolonged campaign.

Several of the topics of the above listing provide the background for any general consideration of the timing that may be allowed for a military venture across the NATO/WARSAW Pact border. In this part of the world, however, moisture and cloud cover will have a particularly strong influence on present day air/ground operations. An unending catalogue of events can be compiled where these two aspects of weather have wreaked havoc on battle plans in Central Europe. Their impact on an ill-planned, ill-timed short war can be even more severe. There is still reason to believe Gen. Eisenhower's conclusion[1] of World War II, "As long as the weather kept our planes on the ground it would be an ally of the enemy worth many additional divisions."

3.2 Storm Tracks Over Europe

The persistent invasion of maritime air over Central Europe becomes obvious from the usual paths[2] of storm centers shown in Figure 3. During spring, summer, and fall they follow a northeasterly track over Germany, slowly and with a low repetition rate. In January these depressions pass directly over the center of Germany, and, although their speed is not significantly greater, their frequency is greatly increased.

The maritime polar air (mP) over the Atlantic Ocean during winter is a relatively warm humid air mass in a neutral or slightly stable state of convective equilibrium. It is already characterized by a high frequency of cloudiness. As it moves eastward the air is modified by the wintertime cooling of the land below it, becoming more stable during the eastward passage. The result is widely spread layers of low clouds except for some build-ups in the immediate vicinity of fronts trailing out of the storm centers.

Storm centers follow each other in rapid succession and develop an extensive, continuous cloud cover as the outcasts of one system merge with those lagging and following. Consequently, it is not all unusual that total overcast periods of several days to a week occur repeatedly with only minor breaks between them.

It should be pointed out that these storm centers do not usually attain the severity associated with those in regions of lower latitudes. The solar elevation at this time of the year is 20 to 30 degrees. Insolation to develop strong cumulus activity is not available. The stable cloud layers also maintain themselves because of this lack of strong heating to dissipate them.

The situation is almost sharply different going into the summer months. Storms are less frequent and their movement over the ground is slow enough so that early morning strata are easily modified by the day's heating from a higher rising sun. As the air

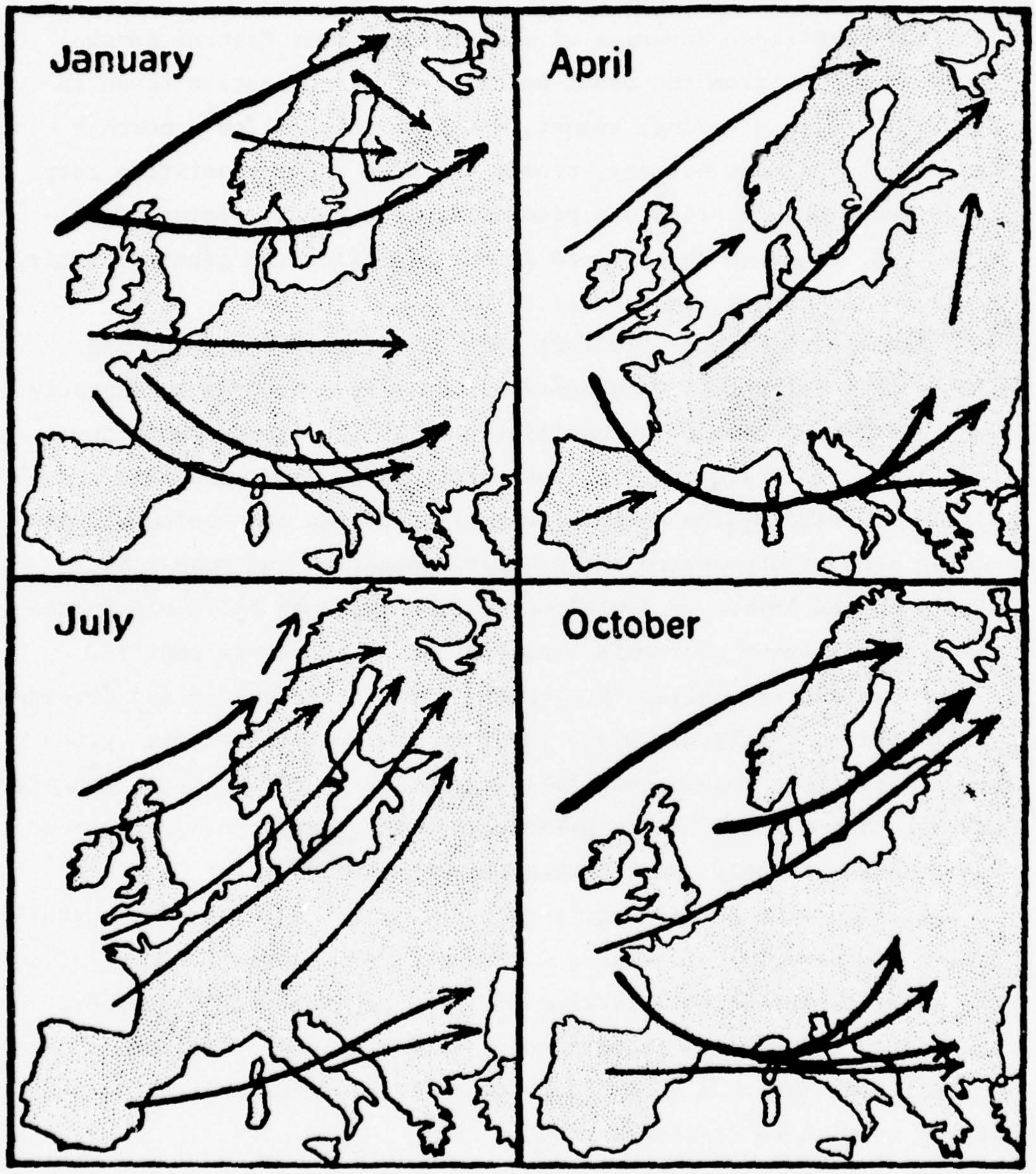


Figure 3. Principal Tracks of Depressions in Western Europe

becomes unstable from heating, the layer clouds dissipate, and later separated cumuliform types develop so that clear to scattered conditions rather than overcasts prevail. This convective process, at the height of summer, leads to thunderstorm activity. On the average, there are about 18-30 days during the summer months when thunderstorm activity should be expected. The diurnal maximum of thunderstorm frequency over land occurs during the afternoon when convection is strongest.

3.3 Wind Flow

The wind pattern[3] over Europe for representative winter and summer months is outlined on the chart of Figure 4. Light westerly surface winds of 10 mph or less predominate over the German area of interest during both seasons. However, one should be reminded that frontal passages will, in the short term, alter both the speed and direction of this average condition. Diurnal and topographical features will also affect the relatively easy flow exhibited by this characteristic pattern.

There is a difference between the winds aloft from the winter to the summer seasons. Wind speeds are still relatively light with increase in altitude. But the direction shifts to a veering northwest wind with elevation in winter. A lifting or orographic flow can then be expected over the generally mounting terrain to the south. This mechanism usually triggers greater cloudiness. In contrast the upper wind during the summer is west to east thus paralleling more nearly the basic contours of the terrain. The necessary lifting of moist air to induce condensation must be exerted by convective heating which tends to develop separated cumuliform cloudiness.

The region of the most probable Forward Edge of Battle Area (FEBA) is, however, sprinkled with peaks, plateaus, basin areas of varying

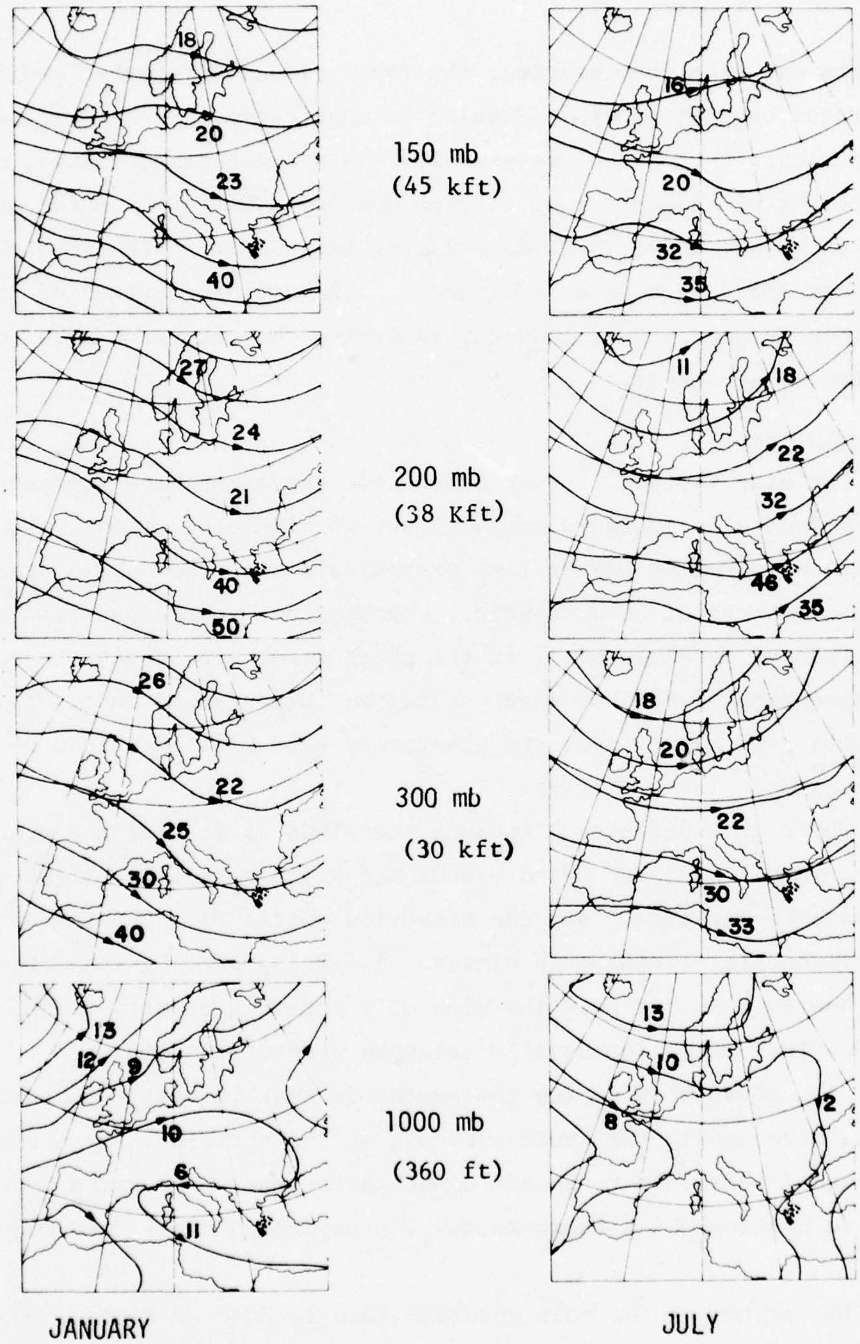


Figure 4. Mean Monthly Winds Over Europe

extent. Its serrated topography, delineated in Figure 2, will stimulate localized vertical motions within the overflowing air mass. Superimposed down-slope and upslope motions within the general transport of moist air will perturb the continuity of the ambient cloud cover. It may be necessary, in this mountainous region, to determine the local wind/terrain effects in producing cloud breaks, cloud thickening and precipitation if it were to be particularly important to military mission goals.

3.4 Temperature

The temperateness of this region is well confirmed by a survey of the temperatures of many reporting centers (cf Appendix). Average monthly maximum summer temperatures are in the low 70's and the monthly minimum temperatures of the coldest winter months hover about 30°F.

Highest absolute maximum temperatures occur about July and August rising into the 90's and touching 100°F occasionally. Many of the latter are observed on the flat plains of the Elbe river or in the high sheltered valleys of the south in areas selected most frequently for troop disposition and air bases. These maxima are not excessively high nor of significantly prolonged duration to affect jet take-off procedures.

The seasonal temperature distributions[2] of Figure 5 reveal one important feature. There is a departure from the normal latitudinal temperature gradient for the winter months around January. The dominant maritime air, which is the main source of warming the European continent in winter, reorients the isotherms to run nearly north and south. Temperatures become progressively colder from west to east to produce eventually the harsh winters of Western Poland and Russia. The 30°F isotherm is very close to the FEBA region but average absolute minimum temperatures may reach 25°F in January and February.

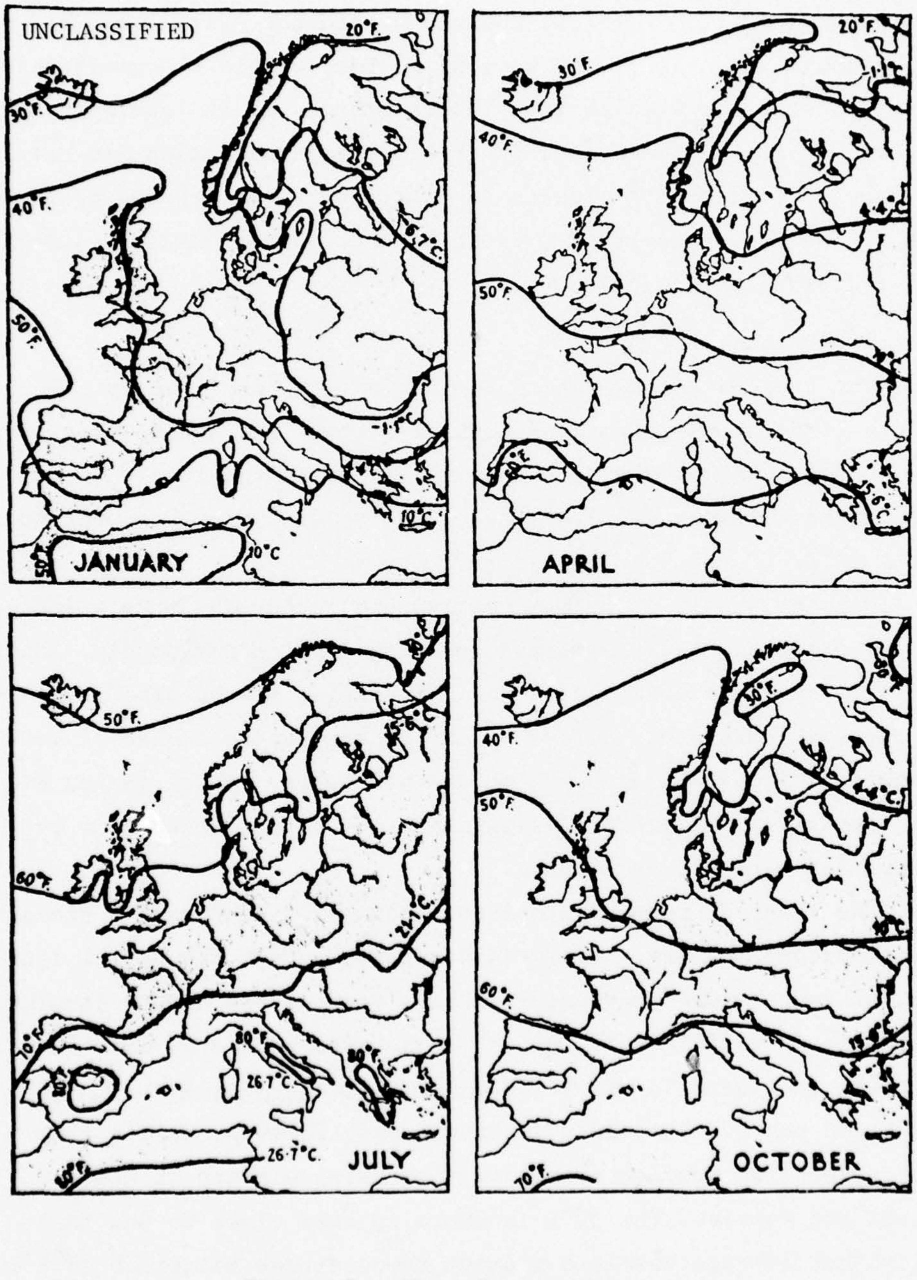


Figure 5. Mean Temperature

During this period the marshes of the plains area and the Elbe river stay frozen for about 30 days. Farther east this cold extends for longer periods. The Oder river is frozen over for as long as 80 days a year on the average. Except for the highest mountain stations, the cold spells are neither long nor intense enough to impose undue hardships on air and ground activity in Central Germany.

3.5 Moisture

Central Europe is one of the most humid regions of the world. Such a characterization in this case is not verified by lengthy or heavy rains. This moisture is chiefly manifest in the continuous high relative humidities and a nearly omnipresent cloudiness.

Relative humidities over the greater part of Germany average close to 70% in the summer and 90% in the winter. The lower humid atmosphere of the maritime flow is blanketed by stratified sheets of low cloudiness. A light drizzle falls frequently from fall to late spring because there is no significant insolation to raise the air to more productive condensation levels.

Precipitation across Central Europe runs from an average of 40" annually in Brittany to 20" or less in Eastern Poland. The former instance associated with the muddiness of World War I has given rise to misconceptions of heavy rains in Europe. The latter instance, well-known to the Germans, allowed for planning a motorized campaign to the Russian border across the dry, baked ground of Poland's summer and fall.

The precipitation in Germany is of the order of 20" to 30" per year. It is nearly uniformly distributed over the year. Summer showers, nevertheless, create an impression that this is a rainy season. The average monthly rainfall approaches 3" for June, July, and August. Such rain, however, comes in concentrated downpours from the convective and thunderstorm activity that is normal for

the season (cf Charts in Appendix).

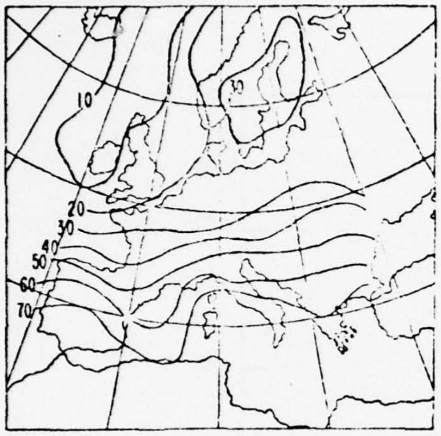
A more usual two-inch monthly average precipitation is received during the winter on the northern plain near the Elbe and southwestward into the interior of Germany. Much of this precipitation from December to February may be in the form of light to moderate snow during the passage of storm systems. Snow in this region is not unusually wet like that of maritime origin in New England northeasters; nor is it unusually dry like that of Mid-Western blizzards leading to inordinate depths. (Records of extraordinary snowfalls have not been available.)

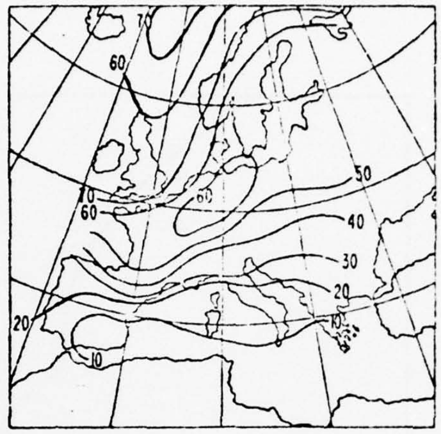
There are exceptions to this evenness of light, distributed precipitation. Most occur in the south towards the Alpine ranges and the Bohemian plateau. Higher elevations and separated peaks provide the necessary orographic lift to winter northwest winds which trigger a secondary precipitation maximum during the winter months, up to 4" in a month, - a figure which can lead to accumulations of three to four feet of snow on the higher mountain crests.

3.6 Cloudiness

One condition of the atmosphere over Germany that approaches a steady state is cloudiness. An analysis of satellite imagery over Central Germany will show clear to scattered cloud conditions occur about 30% of the time in summer and 10% of the time in winter; but overcasts prevail 50% to 70% or more of the time from summer to winter (Fig. 6)[2]; the remainder, of about 20% in each season, is left with scattered to broken conditions. The probability of finding the ground obscured for high altitude reconnaissance is exemplified in Figure 7, a plot by month of the percentage frequency of heavy broken (6 octas sky coverage) to total undercasts.

An opposite view of the sky is given by a series of plots in the Appendix for selected stations[4] close to the border of West

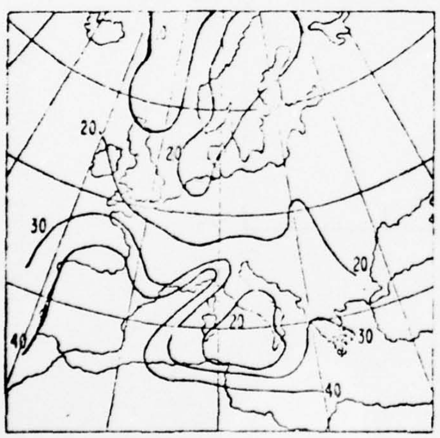


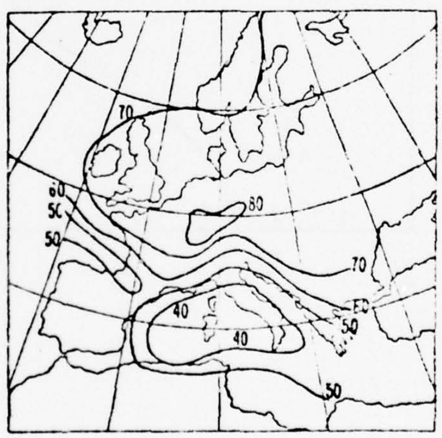


0-3/10

7/10-10/10

July





0-3/10

7/10-10/10

January

Figure 6. % Frequency of Cloud Cover

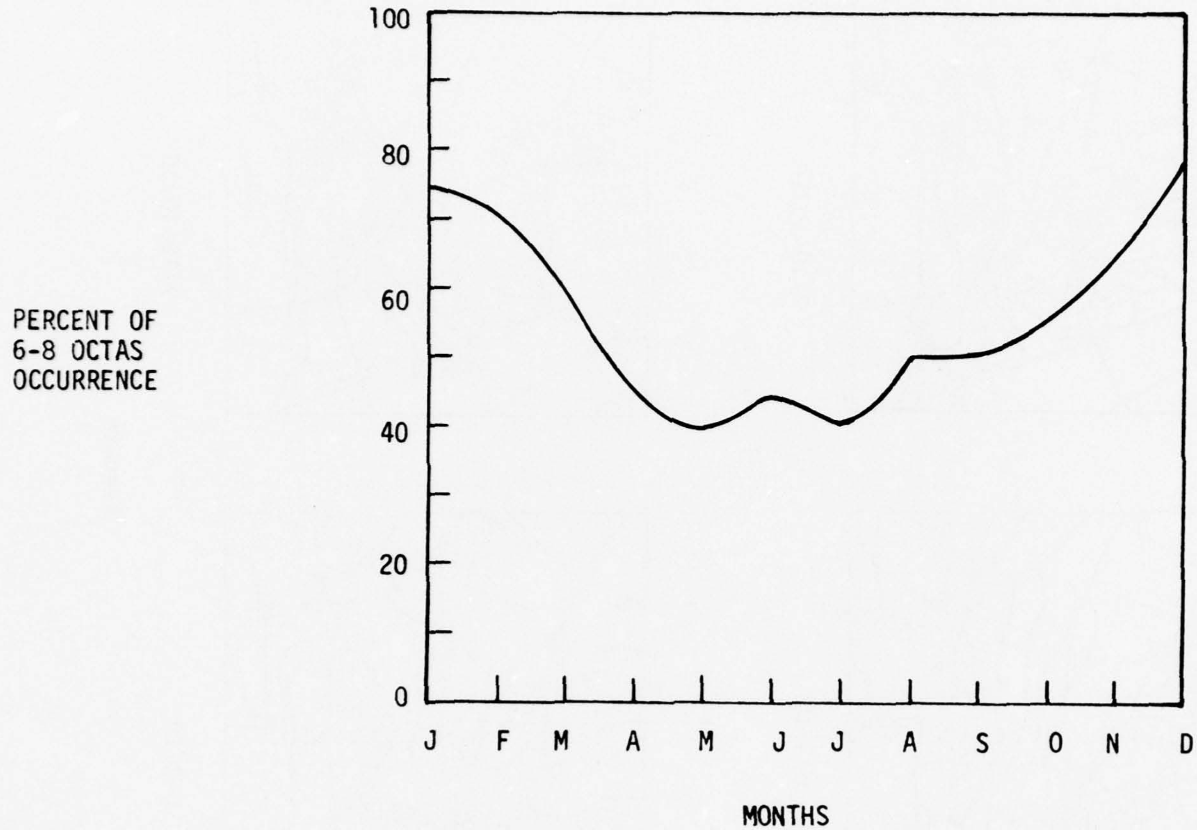


Figure 7. Percent Frequency of Cloud Cover Over Germany

Germany. These display the monthly frequency of ceilings, the bases of the cloud cover measured from the ground, of less than 1500 feet in altitude with visibilities beneath of 3 miles or less. A plot of the type for the town of Hof is presented in Figure 8 for general discussion.

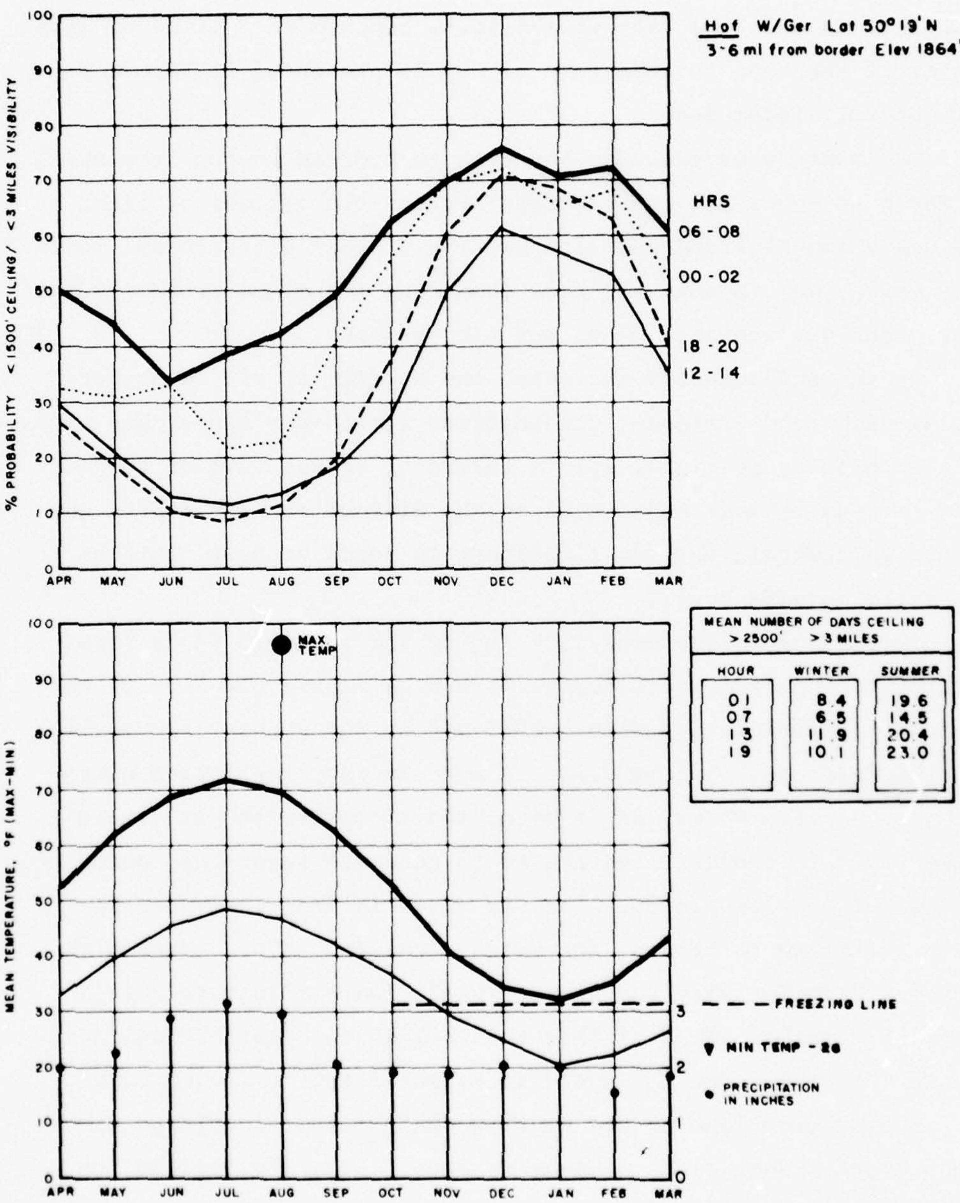
The monthly progression has been re-ordered to run from April to March to emphasize the contrast between the periods of light and heavy low altitude cloudiness. The diurnal differences, where they exist, may be observed from comparing the cloud probabilities near midnight, sunrise, noon, and near sunset.

As the sun descends and sets, the heating at all layers of the atmosphere diminishes, condensation limits are approached, and, if the humidity is right, stable layers of clouds form or thicken. This is usually most pronounced at the diurnal minimum before sunrise. In general, maximum cloudiness is noted at most stations in the early morning hours.

Increasing solar insolation during the forenoon leads first to dissipation of low clouds, which can be nearly complete if the layers are sufficiently thin. Burn-off is the popular expression for this process. In the summer a more intense insolation stimulates convection which, as it were, reaccumulates the available water vapor in concentrated drafts to generate separated, condensed volumes of cumulus clouds. The sky cover in many instances becomes scattered to broken, for which a ceiling is not usually reported. High humidity and strong insolation can lead to a full cover of cumulus. Much of this then begins to dissipate again as the sun descends, and the cycle is repeated the following day.

The observations at Hof do show maximum low cloudiness at 06-08 hours, generally a minimum at noon, and a restabilization of layers from evening into early morning.

It can be seen from the chartings of Figure 8 at Hof (and for



MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

HOUR	WINTER	SUMMER
01	8.4	19.6
07	6.5	14.5
13	11.9	20.4
19	10.1	23.0

FIG. 8 MONTHLY CLOUD COVER / TEMPERATURE / PRECIPITATION

other locations in West and East Germany in the Appendix) that cloud cover with ceilings of 1500 feet or less with less than 3 miles visibility begins to increase from September. Maximum probabilities occur in December and January. A fall off in low cloudiness begins about February but remains substantial through March. The 1500 foot ceiling level plots were used because the data was available and, appropriately, was at the marginal range for reported A.F. operational capabilities.

An insert on the chart presents a seasonal tabular listing of the probabilities of higher cloud ceilings and visibilities, greater than 2500 feet in altitude and greater than 3 miles, respectively. This higher cloudiness extends the probability for which high altitude reconnaissance is denied in both seasons. The larger probability of > 2500 foot ceilings in summer does indicate an adequate air space for possible low altitude reconnaissance and/or close air support.

Data for the Station at Hof is generally representative for stations in Germany and for the region of interest. All the plots show a greater 1500 foot cloud cover incidence in winter than in summer. A closer inspection will reveal the greatest probability occurring during the early morning hours. The probability is about 40% or higher, more frequently it is above 50% and closer to 60% in December and January. The monthly spread is four to five months long at a high occurrence although in some instances the rise may be sharper and of a two month duration. This type of variation is associated usually with the topography of a station.

Locations at the west end of a basin will show a lesser cloud cover because the descending flow of westerly air dissipates on descent. On the other hand, locations at the east end of basins or low lands will show an earlier monthly occurrence and longer persistence of cloudiness because of the forced lifting of westerly

flows. Requirements for more or less cloud cover may have to be evaluated in terms of the military target goal for the season.

Special cases of cloudiness will also occur in the vicinity of large urban areas such as Hamburg (within 60 miles of the FEBA--Fig.9). The cloudiness here is exaggerated by the addition of pollutants generated by industry and home heating. The effects of this heating and pollutant expulsion are noted after the work day has begun; i.e. maximum "cloudiness" occurs at 0900-1100 hours. And the outcasts of this cover may be noticed far eastward of the city, depending on the upper air wind velocity and its dispersive effect.

A quick scan of the charts for the several stations west and east of the NATO/WARSAW Pact borders will show that peak precipitation, peak temperature and minimum low cloudiness occur together. Maximum cloudiness precedes the winter season's temperature lows, and, most of the time, is associated with the months of minimum precipitation.

3.7 Cloud Dimensions/Vertical

A quick perusal of the appended charts for areas within 60 miles of the anticipated FEBA confirms the high probability of winter incidence of low cloudiness over a wide area. This probability mounts towards the northwest and decreases only modestly into the south and southwest. USAF bases are located in this latter section. The presence of this cloud cover is then almost inescapable. Its handicap to flying operations is principally a function of cloud base height, thickness, tops, and prevailing visibility in the ground-to-ceiling space.

Fog, due to clouds touching the ground or produced by radiation, is found about 30 days of the winter in the northwest; about 20 days over most of the remaining West German area.

Fogs and low clouds with low surface visibilities will either

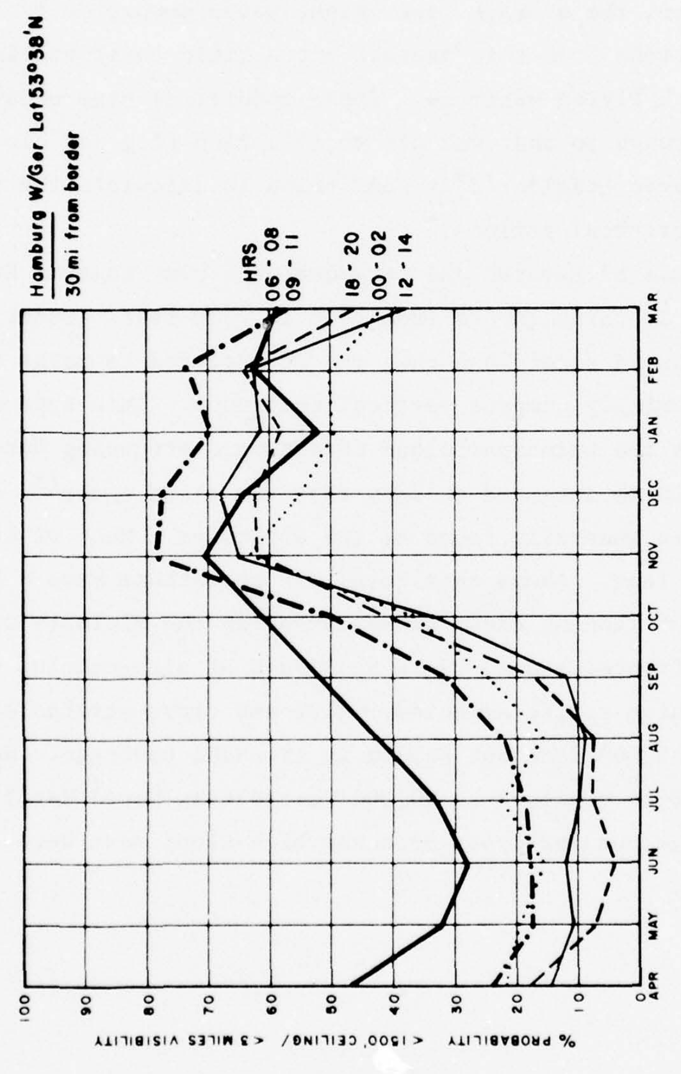


Figure 9. Hamburg's Cloudiness

close down or slow up landing and take-off procedures at NATO air bases. Average annual low cloud base height over Germany runs about 2500 feet. Restricting the averaging process to the worst season, winter, the average base height moves downwards to 1500 feet. Variations from this average often yield lower ceilings which approach flying minimums. These conditions have occurred frequently enough so that weather modification (fog and cloud dispersal) has been considered at USAF bases to alleviate the risk of shutdown at critical periods.

Low clouds of stratus and stratocumulus over Central Europe occur in two or three layers from 1000 to 7000 feet. Under exceptionally humid conditions they may be expected to merge and produce a seemingly compact vertical continuum. This type of cloudiness is the principal cloud formation overrunning Germany.

Figure 10 is intended to show that the cloud cover[5] of Central Europe is generally found at low altitudes. Most of it is below 10,000 feet. Above this level air operations have a high probability of finding clear skies except in the vicinity of storm centers and frontal zones. Here build-ups of alto-cumulus or towering cumulus can be expected. Alto and cirro-stratus are found above 15,000 feet but seldom in extended coverage. Recalls of B-17 and B-24 missions at 30,000 feet during World War II because of large cumulus types or dense high cloudiness were extremely rare.

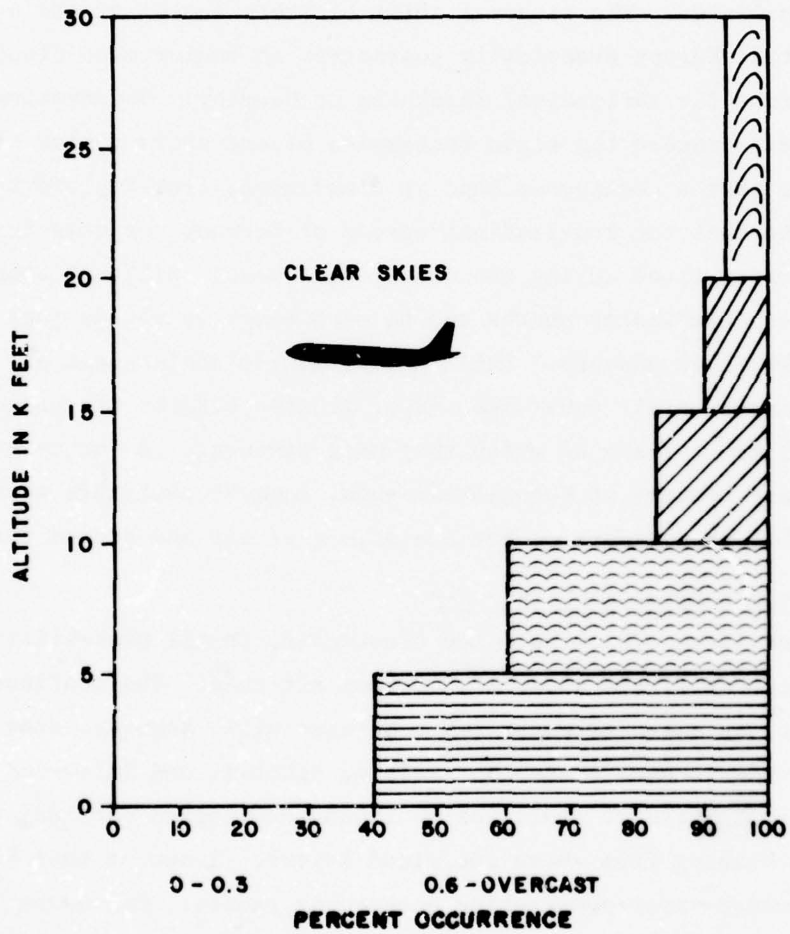


Fig. 10. Cloud amounts within specified ranges of altitude (Europe, January)

SECTION 4

CLIMATE AND MILITARY OPERATIONS

4.0 GERMAN CLIMATE AND MILITARY OPERATIONS

The weather statistics are undeniable: Germany is heavily be-clouded in winter. The seasonal shift of storm center tracks across Central Europe practically guarantees an omnipresent cloud swatch across the latitudinal thickness of Germany. Observations of many years record the rapid succession of one storm center after another so that a continuous band of cloudiness, from England to Russia, overruns the longitudinal spread of Germany for days into weeks, several times during the winter half year. Military operations during the winter months can be more beset by clouds than relieved by their absence. This is a prolonged environment a weather sensitive air power must face; it also affects the ground forces and the terrain on which they must maneuver. A survey of the military history of Europe will show, however, that this weather has an unbalanced effect on the operations of air and ground forces.

4.1 A Weather Sensitive Air Power

Reconnaissance/Bombing: Low cloudiness, in all probability, will not impede flight above 10,000 feet altitude. The continued presence of an extended water vapor barrier will, however, deny high altitude reconnaissance by visible, optical, and infra-red means. Attenuation of radiation at these wavelengths also negates precision bombing from above the cloud layers. Recourse must be found in water-vapor-penetrating detectors: radars. Consequently, imagery will be of coarser resolution or will require a refined interpreting capability; bombing will be on a grosser scale or be singularly restricted in a field of many individual targets or small groupings of targets of variable importance (e.g. a burning or dead tank masked by clouds will look no different than a live

tank to a probing, airborne radar).

Environment for Air Tactics: It seems reasonable to expect that air operations at low altitudes would merit consideration during periods of prolonged cloudiness enveloping a NATO/WARSAW Pact conflict. This paper does not presume to venture into a discussion of air tactics beyond mere indications of the influence of an environment on air operations.

Low ceilings introduce several hazards to air operations where visual contact is a requirement. An optimally camouflaged aircraft, under leaden skies, with a high angular velocity over a ground point becomes a problem for detection from the ground. The problem of detection applies reversibly to the pilot. Illumination and visibilities under low ceilings are also low for picking up and lining up low contrast targets, numerous as they may be. The necessity for visual operation, however, confines the aircraft to the ground to cloud base channel. In fact, the constriction may be more narrowly limiting to the upper portions of the channel for the pilot's best vantage position on a visual target run. This environmentally enforced channelling reduces somewhat the burden of radar tracking from the ground for directing both AAA and small arms fire.

A cloud deck under which aircraft gain some protection from overhead intercepting attacks will also suppress free-wheeling maneuverability of large numbers of close air support aircraft. The risk of collision in high density traffic requires a visual contact range in keeping with air speed and turning radius. Low clouds immediately reduce the vertical dimension of this visual space.

Reorganization of the air striking force at remote distances where greater visible space in the horizontal plane is available will reduce the pressure of the attack. Controlled patterns of

attack out of this recovery area imply a target of opportunity chase or intelligence-governed targetting in a fluid order of battle. In either case the returning aircraft must pop-up again into the constricted vertical space beneath the clouds to locate the target. The problem of visual target detection reasserts itself on each aircraft within a laminar region practically pre-defined by ceiling and visibility for intense ground fire barrages.

A solution to the ground-cloud constriction problem may be a pull-up above the clouds for regrouping or reinstituting an attack. This poses a dilemma. First, the vulnerability to SAM's and air-launched missiles increases in the clear airspace above cloud tops where infra-red seekers can emerge to operate efficiently. Second, this airspace is equally clear to enemy air should they choose to cover the zone for strikes on aircraft penetrating the cloud tops. A good portion of the attacking air power can be harassed in its reforming, become absorbed in a defensive air battle, or badly co-mingled with the air cover so that they are virtually extracted from support of the ground action.

The massive ground attack beneath the clouds presents a somewhat different scenario to fighter aircraft than did train-busting. One-on-one attacks on a tank within a moving army carry with them a cost-ineffective risk where heavy mobile air defense is organic to that army. To be effective single or multiple air strikes will require target intelligence. The scope of the anticipated battle area virtually demands a broad but detailed overview of intelligence in a most readily interpreted form. In most cases this should be obtained from visual sightings, optical or infra-red imagery from spotting aircraft, RPV's or low altitude reconnaissance aircraft. Unfortunately, a winter season of low ceilings, poor visibilities, abetted by ground forces' air defenses can make such intelligence gathering spotty or futile. An ultimate consequence of low cloud

ceiling may be a drastic curtailment of close air support because of procedural or intelligence limitations. Advantage in a ground operation may then be decided by the superior ground force alone.

It should be recognized that in most cases aircraft require lower ceiling/visibility minimums than do other weapons. Purportedly, high speed attack aircraft need 1000 feet and 3 miles visibility. The new close air support aircraft[6] were developed for an operational capability of 1000 feet/1 mile visibility and are, at 200 knots, hopefully effective at 500 feet and 1 mile visibility. These are specifications on the aircraft and do not appear to incorporate human factors.

In contrast, the laser/EO guided bombs of the S.E. Asian conflict require a higher altitude for target detection, and to insure seeker lock-on. Laser ranges to the target of 10,000 to 50,000 feet have been used. The lower range, in Europe, would immerse the pointing, circling aircraft very deeply in a hostile environment; the larger ranges would, more than likely, find the aircraft buried in the low, winter cloud layers.

Summer cloudiness will not be discussed at length since it offers fewer impediments to military flying. Ceilings of 1500 feet or less, much of it during morning hours, occurs about 10% to 20% of the time over the total area; these are raised or dissipated by heating during the day. Still, summer ceilings, in general, are observed up to 40% to 60% of the time over large portions of Germany. The average base altitude of such clouds, however, rises to 2500 feet. Moreover, the cloudiness does not form in persistent extended layers. Solar heating develops a broken cumulus patterning. The sky coverage requires reporting of a ceiling but although these clouds with frequent breaks and higher base heights might perturb they would not generally deteriorate military operations. The more important consideration relates to the prediction of winter weather in this theater.

Prediction in this case means improvement on the climatological statistics as known by the opposing sides. An advantage can be taken if the desired statistical probability is known to be rising to the fore. Present day weather watch aided by detailed, computerized weather observations and analyses provides for more nearly accurate anticipation of advancing weather patterns. This is further supported by satellite observations, through imagery and/or atmospheric probings to the ground, which allow better judgement that weather is setting in that would favor or void the launch of a military operation, an impulsive thrust, an overwhelming advance, or a campaign.

4.2 Terrain Sensitive Ground Force

A weather dependent aspect of military operations is tractionability. This is the capability of a soil to support the passage of heavy vehicles. Seasonal variations in tractionability are closely governed by soil type and soil moisture content. A soil may be very permeable to water falling on or flowing over it. As permeabality decreases a water table is maintained at levels that approach the surface more closely with soil of a greater moisture retention capability. Moisture retention close to the bearing surface then decreases if the surface water is not replenished frequently and if a good rate of evapo-transpiration exists.

It has been suggested that the NATO/WARSAW Pact border region can be divided rather grossly into three types of soil. A narrow northern strip along the Baltic Sea coast is sandy. This fringe area gives way quickly to a glacio-lacustrine plane which extends south of the Celle. Just below Hannover, the thrust-folded and contorted bedrock hills of the Harz mountains begin to rise into the Bohemian massif.

Sand is extremely permeable to moisture. Its trafficability is not a serious problem to properly equipped vehicles. In fact, it improves with rainfall.

The gently rising plain area contiguous to the sand fringe is less permeable to water and does begin to support a water table close to its surface. Moisture added to the surface before evapotranspiration has had a chance to work will lead to a plasticity under repeated heavy traffic; a long lasting mud will be produced by traffic almost immediately following heavy rains.

The granitized, sedimentary mineralized composition of the bedrock mountains does not succumb to muddiness quite so readily under modest rainfalls. However, the high, wide basin regions can overlie surface water tables with a clayey top soil and yield muddy conditions under a heavy burden of armored equipment.

This subject is doubtlessly more complicated than sketched above especially where a long river and mountainous border region can exhibit macroscopic area differences in juxtaposition to one another. It is a particular topic within the mission scope of Waterways Experiment Station, Corps of Engineers, U.S. Army at Vicksburg, Miss. This organization has produced a detailed analysis[7] of the various categories of soil moisture conditions in Poland showing how they change from month to month as a result of climatic variation, and how they apply to tractionability conditions. Because the scope and level of this detail for German soil has not been readily available a comparison by analogy might be useful.

On the same European coastal plain, the Germans found no impediment to armored traffic through Poland in late summer where the

rainfall is less than 20" annually. Armored units after early spring rains in N.W. France, the lowland countries and N.W. Germany were known to have churned the surface into deep mud which dampened the progress of an attack. This German border region lies between these extremes.

Precipitation over the central or plains strip of the two Germanies average about 2" per month. A lesser quantity falls during the winter months but is rather evenly distributed over the month. The evapo-transpiration rate (in winter) is low because of relatively low air temperatures and an overrunning air mass characterized by high relative humidities (in the 90%'s). Seasonal drizzle and snowfall, generally on unfrozen ground, permeates the surface layers very slowly, even to a very high water table. Conditions are appropriate for some conversion of the surface layers to mud. A mechanism for this conversion is readily found in a repeated, heavy traffic over the surface.

Precipitation during the summer is less evenly distributed. Most of this falls, up to 3", in June, July, and August, out of the several thunderstorms of the season. Although the relative humidity is lower, and the skies clear rapidly of clouds and open up to greater insolation, the pressure of armored vehicles soon after such cloud bursts will generate a long lasting heavy mud. Note that the prediction of a thunderstorm season is not easily followed by precise prediction of the scope, intensity, and time of short-lived deluge.

4.3 Operations - Weather Imbalance

The paradox of Central Europe's weather is that heavy rains do not usually fall during the periods of highest cloud incidence. The imbalance of the effect of weather on air and ground operations in Germany closely parallels this deviation from the expected. Air operations can be most seriously affected in Europe during the

periods of great cloudiness. Ground operations, of themselves, where heavy armor and transport is abundant, will be more handicapped following the periods of moderate to heavy summer rain. It is hoped that this weather survey shows that the periods more nearly favorable to each operation are offset by a season: winter for clouds, summer for rain.

SECTION 5

ENVIRONMENT OF WARSAW PACT/GROUND OPERATIONS

5.0 APPLYING THE ENVIRONMENT TO WARSAW PACT AIR/GROUND OPERATIONS

Combined Warsaw Pact air/ground operations on the offensive should also, among other considerations, be appraised for their potential of success within the weather regime of the preceding review. The meteorological environment overspreads the total operation but the nature and magnitude of its influence varies among the functional parts of the operation. Some of the functions of the military offensive operation that merit particular environmental assessment include the following:

- CBW operations
- Mobility of heavy equipment and troops
- Reconnaissance
- Air Support of ground forces
- Visual targetting for SAM's and AAA
- Target spotting for artillery and air strikes

Inasmuch as a military operation proceeds in stages, three scenarios have been suggested, namely: frontal moves of (a) 0-5Km/day, (b) 10-30Km/day, (c) 50-100Km/day. Generally, there would be little reason to expect any real variation in the seasonal climatology of a broad region in such incremental ground steps. The average weather of this study will apply almost uniformly for the first day of each of the scenarios, and for several days of the slower movements. The lower rates of military progression do imply heavy resistance which could introduce degrading alterations of the environment by injection of atmospheric pollutants. And several frontal leaps of 100Km/day would soon outrun both the terrain and climatology of the border region by the second day. On the whole, however, the effects of the environment will not be addressed within the formal matrix of the scenarios except in special instances.

5.1 Capability to Mount CBW Operations

WINDS/INVERSIONS: The effectiveness of a CBW attack depends on the capability of the near surface air to sustain an aerosol over a locality. Stagnant or light winds and a low inversion are two of the more important atmospheric parameters. Light winds are preferable because they provide some lateral diffusion of the CBW products without excessive transport from the target area. The inversion* inhibits the dissipation of the aerosol's potency by vertical diffusion.

These conditions are found frequently over the plains portion of Germany. Predominant wind speed range is of the order of 4-10 knots occurring, most often, before dawn. This is also the period when low inversions are to be found. In summer they are usually established by ground radiation losses; in winter, they flow in, as it were, with the cloud layers that become even more stable as they pass over colder ground. The best opportunities for CBW use diminish as wind speed increases toward the maximum solar heating part of the day, at weather front passages, around mountain tops and in narrow gorges.

TOPOGRAPHY: The CBW is also subject to the topography for its employment. Its application in support of an incremental advance of the several scenarios must be evaluated in terms of terrain. This is particularly true in the mountainous regions. The ambient wind field and inversion levels can be overcome by local upslope and downslope motions. Hilly bowls, mountain basins, and deep valleys seem to be natural receptacles in which to entrap a heavy aerosol. Cool night and early morning air flowing down slopes would contain and prolong the effects of a CBW. At sunrise, however, upslope transport would be instituted as solar heating increases,

---

*Surface layers are cooler than higher layers of the atmosphere.

thereby driving the aerosol out of the natural depressions.

LAND/WATER BOUNDARY: Similar transport of the CBW aerosol can be expected if it is deposited in the vicinity of a land-water boundary. On-shore and off-shore breezes can be expected between night and day, depending on the relative heat radiation properties of water and land for the season. The force of such land-water winds can override the ambient atmospheric wind flow in the proximity of rivers, ponds, marshes.

Admittedly, these are small, localized effects. But the CBW is a weapon that produces a localized effect despite its damage radius being greater than that of conventional explosives. Its use in support of small frontal movements depends directly on the facing topography and the minute, but sensible changes of local, diurnal weather.

In every instance the wind velocity becomes an important factor for the persistence and transport of aerosols. Since winds are generally westerly, light winds of 10 knots or less can overrun the attacking force within a few miles of the CB targeted area. Winds of greater than 10 knots within a channelled area of clouds and surface would also overrun attacking forces despite aerosol dispersal if a greater quantity of CB's were laid down to be effective over a large target zone. The force using CBW should be protected against its own weapon effects, especially if it is within 10 miles of the target zone or if it will enter such a zone within a few hours.

5.2 Physical Movement of Heavy Equipment and Men

SAND STRIP: Winter and summer, dry and wet weather, the narrow sandy fringe offers no particular difficulty to repeated traffic of properly equipped track vehicles; except that progress is

slow through such a medium. Some equipment might be specifically designated to such employment and become less useful elsewhere.

COASTAL PLAIN: Difficulties begin to mount southward at the transition zone, on both sides of the Elbe, where frequent marshy areas interfere with a continuous broad frontal advance. Even the firmer ground around the marshy patches is underrun by a high water table. An evaluation of U.S. Army trafficability(8) for such a soil type indicates that a repeated passage of about six heavy military vehicles in the same track would deteriorate the surface so as to impede continuing movement during fall and spring months. The light snow and the short duration frozen winter crusting can also be broken down quickly to the inherently high moisture content soil. Soil moisture conditions might fluctuate during the drying spells of summer but would be rapidly reconstituted particularly after heavy area thunderstorms. A sudden thunderstorm would mire armored vehicles very quickly in this area.

Such conditions would prevail as far west as Kiel and Hamburg and beyond; as far south as Celle and Hannover. Broad advances, beyond gains of 3 to 6 miles, would most likely have to be supported along road systems. This would be particularly true if the advance is perturbed by a milling action in place or if a mass overland withdrawal of heavy vehicles precedes the advance. The plain's surface cannot take a heavy, repeated pounding before it turns to heavy, foot slogging mud in any season other than an unusual hot, drying summer.

SOUTHERN HILLS: The rising terrain in the south affords a more nearly constant underfooting for vehicles in all seasons. On the other hand, the shape of the terrain and forests might offer a constraint in themselves to any rapidity of movement.

In winter, however, it should be noted that an advance might also have to originate on the deeply snow covered parapet of the

Bohemian plateau. En route, the more separated taller peaks of 3000 to 4000 feet would bear snow depths of 30 to 40 inches from December into February. Lower mountain tops, down to 2000 feet, could be covered to two foot depths. Attacking traffic might then be required to skirt around such domes, constricting movement to valley roads and lower slopes.

THE ELBE: The crossing of the Elbe deserves some attention. Precipitation throughout this region is quite uniform. Floodings or lower water levels would then be unusual. Still, a spring crossing must still take into account whether or not the winter mountain snow had been heavy or extraordinarily light in anticipation of any flooding or fast flowing river water.

Military engineering of the crossing of the Elbe might be facilitated over a frozen river. It is reiterated that the brackish water of the marshes and the lower Elbe freezes at relatively high temperatures. Averages do show that much of the Elbe coursing through the plains area is frozen over from early January into mid-February, as are the water areas leading into Lubeck.

In general, the soil conditions on both sides of the Elbe will most likely allow 3 to 6 mile advances regardless of the season. Distances beyond this will probably depend on pressing and enlarging support from the rear. Severe opposition in front or exceptional, repeated rear echelon traffic will break down the soil, restricting traffic to bearable road system surfaces, consequently stringing out the support from the rear echelons.

5.3 Capability to Perform Reconnaissance

Meteorological conditions that will allow or deny a capability to perform reconnaissance will apply with equal impartiality to both sides.

SUMMER: Late spring through summer to early fall affords the

best opportunity for reconnaissance by visual or optical means. A poorer period occurs most often just before to a little after sunrise. Low hanging clouds formed at the diurnal temperature minimum and nocturnal radiation fogs in river valleys, both despite their thinness, will obscure optical and I.R. inspection of the ground. Solar heating will dissipate such phenomena and will then erode the influx of thin stable cloud layers through mid-morning. The usual mechanism of solar heating is then to stimulate convection which first produces separated cumulus forms. If the humidity is high in the lower layers the convection may be severe enough to generate thunderstorm cumulus. German skies of this season are generally porous enough for reconnaissance penetrations.

The longitudinal differences from 60 miles west to 60 miles east of the border are small enough that the effects of solar heating on both sides may be considered to be similar at any given time. The principal difference may occur with summer frontal movements. Since the rate of travel of such fronts is about 30mph it is possible that there will be about an hour's lag in the masking and unmasking of a transitional 30-60 mile wide strip from west to east.

Accordingly, the summer half year is a good period for reconnaissance from higher and lower altitude aircraft. Skies will be clear to scattered for 30% of the time. The 40% of the time the sky is scattered to broken occurs in the late morning and evening and with the few frontal passages. With scattered to broken clouds it is possible to obtain cloud-free-line-of-sight (CFLOS)[9] reconnaissance from high altitude aircraft. This technique (which is SOP) is most efficient when the aircraft is flying directly over the target ground. In other words, a high flying aircraft may obtain good reconnaissance out to about 10 miles while flying within and parallel to its own border. The line of sight capability under 50% to broken cloud conditions will break down as it tries to probe deeper laterally

into enemy territory. Cloud geometry will shadow the cloud holes over more remote target scenes. To extend the CFLOS reconnaissance direct flights would have to be made over the target areas farther out from the FEBA.

Again, except for frontal areas, low cloudiness during the summer period will allow a reasonable altitude and sufficient illumination for lower altitude reconnaissance beneath the clouds. Cloud bases of the scattered to broken conditions are more likely to be found closer to 3000 feet or at higher altitudes over the plains area, rising to 8000 feet MSL and higher over the mountain terrain. Visibilities and light levels during the day will be adequate to image laterally out to 6 miles from the border. Detection at greater ranges places greater demands on visual acuity and camera resolving power so that overflights would be necessary.

WINTER: Winter is a completely different situation for reconnaissance. Cloud cover continuity rises to a 70% (and as much as 80%) occurrence probability over most of the region (i.e. 70% of the days of the month and not 70% sky coverage of each day). Improvements over these values are spotty and due to peculiar topographical features. Dissipation of clouds to heating is minimal because of low solar elevations. Frequent frontal passages flow their cloud layers in merging succession. High altitude reconnaissance is at best available only by chance through the rare breaks between series of frontal passages. Dawn and pre-dawn reconnaisance offers the lowest probability for any success with optical or I.R. imagery.

Low altitude reconnaissance will be confined below 3000 feet altitudes up to 60% of the time and possibly down to 1500 feet approximately 50% or more of the time. Morning cloudiness can be considerably lower in altitude, and very nearly 30 days out of the

90 actual winter-month days can be plagued by fog until mid-morning.

Continuous heavy cloud cover, which can persist for several days at a time, will decrease maximum illumination levels to below 1000 foot candles (from an 8000 foot candles maximum for summer noon). Since this affects target brightness and contrast (of drab, colorless, military targets) visual detection becomes increasingly difficult. Special requirements will be necessary for photographic imagery and for response time and resolution with low light level T.V.

At 2000 feet altitude, flying within and parallel to one's own border, reconnaissance much beyond 3 miles will be sorely beset by recognition problems. Low flying vehicles, aircraft and RPV's crossing the border to gather imagery intelligence must experience small arms fire from extensively deployed short range air defense weapons.

Reconnaissance from low altitudes and at low illumination levels suffers from degraded imagery outside of a very narrow ground swath width along the flight path. Winter cloudiness may then place demands on a great number of reconnaissance aircraft or a large number of retracing flights out to 60 miles in a hostile environment. Or, flights may have to be precisely vectored from prior information on critical target areas, or from information from SLAR, RINT, etc., reconnaissance gained from above a cloud deck. The piecing together of these numerous and diverse imagery inputs may make it difficult to assess the total scope of a ground action.

5.4 Air Operations Support of Frontal Movements

SUMMER: This is the less cloudy season of the year although the observations show broken to overcast skies cover Germany up to 60% of the time. The character of the sky cover differs from that

of winter in two respects, namely: base height and cloud type.

Low cloudiness of 1500 feet or lower ceiling heights occurs over Central Germany with a maximum probability of 40%. The average is closer to 30% and chiefly during the early morning hours. A survey of the charts in the Appendix shows the effects of burn-off into the afternoon with a decrease to 20% of low cloud encounter. This probability decreases to 10% in Southwest Germany where many U.S. tactical fighter bases are located. During the summer, then, low clouds and ceiling do not limit take-offs or landing of aircraft significantly.

The total 60% cloud cover figure of summer includes these low clouds and a large proportion at higher elevations that leads to reporting higher ceilings. The tabular insert on the appended charts will show that, during this summer season, ceilings of 2500 feet or higher are observed with visibilities of 3 miles or greater up to 20 days out of 30 per month. Maneuvering space under such elevated ceilings is more nearly adequate for close air support operations, including high speed aircraft.

Summer cloudiness, regardless of ceiling height, shows a lower tendency to flow in continuous sheets. The sky pattern most frequently observed is a profuse dispersal of cumulus clouds. Monthly probability figures of sky coverage become very representative of the total sky coverage to be found on most of the days of that month.

In such skies a high protective air cover can be employed efficiently. Close attack air support is less tightly bound by looser ceilings. Regrouping tactics through and above such clouds would experience fewer problems in maintaining visual contact. In general, all air operations would be more manageable including support of better illuminated ground operations.

WINTER: September into November, and through February, layers of clouds move in to provide a thorough blanketing across the flat northland for several days to more than a week at a time. Continuous cloud cover with ceilings below 1500 feet and visibilities of 3 miles or less obtain up to 80% of the time in N.W. Germany, up to 60-70% of the time over the border areas, decreasing modestly to the east. Again the probability of occurrence is highest just before sunrise; but reduced insolation provides little dissipation or heating to raise ceilings or develop breaks in the clouds. December and January provide the worst conditions both in high percentage of cloud continuity and ceilings below 1500 feet.

The situation is only a little improved over the southern hills in terms of probability of occurrence. A decrease to about 50% in the cloudier months occurs principally over the basin areas where the cloud flow undergoes some subsiding dissipation by descending over the basin rims or down the lee side of mountain slopes.

The 1500 foot ceiling frequency practically eliminates the use of high speed aircraft which require more maneuvering space. Their relative high speed may reduce their operations to a one-on-one attack mode in close air support except in the fortunate occurrence of swift detection of a highly clustered set of ground targets. Since air-to-air combat under 1000 foot ceilings seems impractical the air support for a ground attack might well be a concerted effort of a higher aircraft cover to attack the enemy's close air support aircraft emerging above the tops of the low cloud cover for regrouping.

Close air attack aircraft capable of operating at 500 feet and at less than 200 knots must, nevertheless, detect and attack a distributed force under conditions of low illumination and visibilities of 3 miles or less. Ceilings limit the vertical height of their air space channel so that small arms and Anti Aircraft Artillery (AAA)

search-and-fire programs can be confined to a narrow vertical space. It would appear that in such a limited air space, attacking aircraft maneuvers could be severely hampered by short line cabled balloons dispersed on heavy moving equipment as a ground army advances.

Week-long palls of low clouds over Europe in winter are common. They occur several times in a season. At no other time in history can the onset of this, or other, weather be better recognized than today from weather satellite observations. There is a military advantage to be taken from the settling in of the obscurations such prolonged palls will produce.

These winter clouds progress from west to east. Upon weather satellite detection of this movement, while still far over the Atlantic Ocean, last, updating reconnaissance missions could be made across the border into NATO territory under the higher leading edge of the cloud flow. As the cloud deck sweeps in and finally overlays East Germany, ground forces can be marshalled over a road system, if not secretly at least not exposed in clear optical detail, for several days. An attack early on a morning, when cloud ceilings over the FEBA are very near their lowest, would curtail or practically eliminate close air attack on these forces. Higher flying aircraft could still attack fixed targets, penetrating through the rising cloud layers farther west, far in advance of the ground thrust. In proper season, then, military operation can be forced in the direction of ground superiority.

5.5 Capability for Visual Target Acquisition

This capability refers to the visual operation of Surface-to-Air Missiles (SAM's) and AAA and to the visual spotting of air and artillery targets. The immediate limitation to this capability, whether the observing post is on the ground or aloft, is the geometry of the situation. Cloud bases determine the geometrical constraint. Cloud ceilings and thickness then influence the full attainability of

this linear range by the amount of target illumination that is permitted to enter the field of view. Finally, the extinction properties of the environment between the ground and cloud base environment may or may not further foreshorten the range at which actual visual detection and tracking can be accomplished.

SUMMER: Average weather conditions during the summer season, once morning clouds have lifted or burned through, offer no serious impediments to the usual visual methods for acquiring targets. Cloud ceiling are sufficiently high, 3000 feet or higher, with surface visibilities in excess of 3 miles, about 60% of the time, so that optical aids can be used to their designed operational limits.

Aircraft spotting from positions within and parallel to an army frontal position could penetrate visually to the ground out to 5Km or more from the front. If there were an impediment to spotting for artillery and aircraft strikes out to these distances it would arise in the combined effect of a cosine defect in target dimensions and visual acuity limitations. Since this beneficent environmental state would prevail for 100 or more kilometers, flights could be made over enemy territory for a more nearly downward look at target areas, risking, of course, air defenses. Higher altitude flights from mid-morning on would find a patchwork of cloud cover. If the aggregate of cloud area made up 70% or less of the field, effective target spotting could be made through the cloud interstices[9] from above the cloud tops. The CFLOS summer opportunity is available over most of Germany in excess of 50% of the time. The range for observation flights from the front may, however, be interrupted either by frontal approaches or thunderstorm build-ups and aggregations.

Visual control of SAM's and AAA requires exploitation of the same visual conditions and ranges but in the reverse direction. Ground observing posts, particularly in the mountainous sections, can suffer from blocking or shadowing effects of terrain features.

Apart from such obstructions both mountain and plains observing sites should find a free vertical space of good visibility to the 3000 foot or better cloud base altitude up to 60% of the time. During the late morning and early afternoon hours the slant ranges for missile and aircraft detection can extend to 5 or more miles. As cloud build-up progresses and sky cover increases from scattered to a broken state the clouds will begin to interfere, punctuate or finally block visual tracking of aircraft or missiles coming through the cloud deck. When clouds have accumulated so that a ceiling (about 70% coverage) is reported the visual slant range will then be proscribed by the ceiling height.

Climatologically there is a 40% to 60% probability, from south to north, that ceilings of 3000 to 6000 feet altitude will overflow Central Germany. With the accompanying reduction of slant range it is likely that some radar detection aid will be necessary if the refinements of visual tracking can be applied for t' brief interval an enemy vehicle plummets into view beneath the cloud layer.

WINTER: The high probability of low winter cloudiness severely impairs aircraft spotting of targets for air or artillery strikes. A 1500 foot or lower ceiling, poor illumination, visible light attenuation in a humid atmosphere, aggravated further by battle-field pollution, all of these will combine to reduce the slant range spotting capability in the intervening air space to 2 miles or less. Visual penetrations beyond this will require low altitude overflights of enemy territory with the attendant risks. Overflights above the cloud deck can be absolutely futile up to 70-80% of the time because of the solid continuity of stratified cloud decks. Not 70-80% of the time of a given day but 70-80% of the days of the winter months.

SAM and AAA visual fire control against missiles or aircraft descending through the clouds may be practically impossible. Ceilings

of 1500 feet on the average allow too little time, on the final plunge of missile delivery system, for effective visual fire control. Some visual fire control may be applicable against aircraft flying within the ground-cloud base channel if a radar aid is used for initial detection and tracking at a longer range.

A last point meriting mention is the "smart" weapon. Exclusive of the Maverick most of the others require altitude for acquisition and sure lock on the target. These conditions are not obtained over much of the winter season. Ceilings and visibility require the pointing aircraft to move in close to the target and, thereby, become well-immersed in the hostile environment.

It should also be pointed out that low clouds trail water vapor drifts. The ambient environment is also of relatively high humidity. Laser pointers, susceptible to water vapor attenuation, are subject to severe loss in efficiency in such a wet atmosphere.

SECTION 6

SUMMARY

6.0 SUMMARY

1. Winds and inversion conditions in Central Germany are right for the use of CBW. The weapon can be detonated behind NATO forces and the west-east flow will drift the aerosol over these forces. A proper accounting must be made, however, for topography, diurnal wind conditions, and protection against the same westerly flow of air passing over WARSAW Pact troops.

2. Large movements of heavy equipment and troops must be preplanned in terms of the terrain. Surface water in the northern plains constrains a broad advance to the firmer paths; repeated tracking on the allowable trails very quickly breaks down the surface underrun by a high water table at any time, but especially on the heels of summer downpours. Winter snows in the southern mountains will confine traffic to the natural valley or man-made road systems. Clouds and precipitation otherwise will not be ruinous to ground action.

3. Winter low cloudiness will not permit or will limit the scope of low altitude reconnaissance to below 1500 feet about 70% of the time in the north, about 60% of the time in the south. Morning reconnaissance opportunities will be worse. High altitude reconnaissance above the clouds may be impossible up to 80% and 60% of the time in the north and south, respectively.

Summer reconnaissance at low altitude after sunrise will be possible under 2500 foot or higher ceilings up to 70% of the time. The summer lattice pattern of clouds will permit high altitude reconnaissance of about the same order using CFLOS of technique.

4. Low cloudiness, fog, poor visibility can hamper the takeoff and landing of U.S. fighters out of their bases 25% of the winter mornings. The figure rises to 30% of the time for East German

bases. Close air support of ground forces in the northern plains will encounter a cloud base height of 1500 feet or less up to 70% of the time, 2500 feet or less up to 80% of the time. The probabilities for low ceilings in the mountains diminishes to 60% or less and prevails for a shorter period, generally, December to February. The feasibility of air support is a function of the close air support capability under the prevalent cloud conditions and the willingness to run the risks. The effectiveness depends on the rapidity and accuracy in picking up salient target areas -- a condition which can be compounded by the number of targets on the plains, and yet be simplified in the mountains where limited roads will funnel target streams.

5. The low ceilings of winter seriously reduce the opportunities to operate SAM's and AAA visually and impair the range for aircraft and artillery target spotting. An enhanced capability in these respects obtains in the summer season as cloud incidence decreases, ceiling heights rise, and the cloud structure breaks up into an irregular lattice of cumulus forms.

Finally, the following tabular summary combines and interpolates data from throughout the paper. It must be taken as illustrative because there is ever a latent propensity to hedge on weather predictions particularly where a force fit seems to be required. The quantitive results are somewhat arbitrary for this reason and because they depend in part on some broad interpretations of military capabilities.

Table I

Tabular Summary

Capability	0-5 Km/Day	10-30 Km/Day	50-100 Km/Day	Comments
CBW				
Summer-Plains	50%	50%	?	Subject to winds/terrain
Mts	30%	30%	?	? -- too remote
Winter-Plains	60-70%	60-70%	?	Freq. inversions
Mts	30%	30%	?	
Ground Movement				
Summer-Plains				R⟩ = Thunderstorm
1st day-Recent R⟩	Go	Marginal Go	Marginal	Massive withdrawal,
No R⟩	Go	Go	Go	pounding action
2nd day-Recent R⟩	?	?	?	
No R⟩	Go	Go	Go	
3rd day-Recent R⟩	?	?	?	
No R⟩	?	Go	Go	Tortured ground
Winter-Plains				
1st day	Go	Go	Go	
2nd day	Go	Go	?	West of Hamburg terrain
3rd day	Go	Marginal	?	degrades

Table I (Continued)

Capability	0-5 Km/Day	10-30 Km/Day	50-100 Km/Day	Comments
Ground Movement				
Summer-Mts				
1st day	Go	Go	?	Terrain -- broad frontal
2nd day	Go	Go	?	movement doubtful, lined
3rd day	Go	Go	?	out rear echelons
Winter-Mts				
1st day	Go	Go	?	
2nd day	Go	?	?	Terrain, snow impediments
3rd day	Go	?	?	
Air Operations				
Summer-Plains	60-70%	70%	70%	Close air support presumed
Mts	70-80%	70-80%	70-80%	
Winter-Plains	30%	30%	20-30%	
Mts	40-50%	40-60%	40-60%	
Recon. Capability				
Summer-Plains	70-80%/70%	70-80%/70%	60-70%/60-70%	High altitude/low altitude
Mts	80%/70%	80%/70%	80%/70%	
Winter-Plains	20%/70%-80%*	20%/50%	10-20%/30-50%	*limited value close to
Mts	40%/50-60%	40%/50-60%	40-60%/40-60%	front

Table I (Concluded)

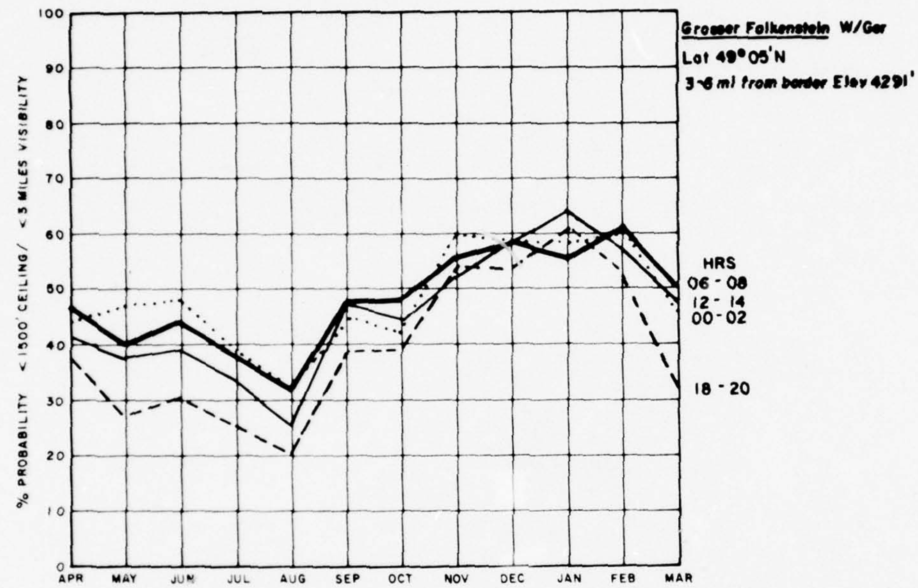
Capability	0-5 Km/Day	10-30 Km/Day	50-100 Km/Day	Comments
Tgt Spotting				
Summer-Plains	90%*	70%	60%	*immediate frontal
Mts	80%*	70%	50%	vicinity
Winter-Plains	70%	50%	30%	
Mts	80%	70%	60%	
Visual SAM/AAA				
Summer-Plains	60-70%	50-60%	50%	
Mts	50%	50%	50%	
Winter-Plains	30%	20%	10-20%	
Mts	40-50%	40%	30%	

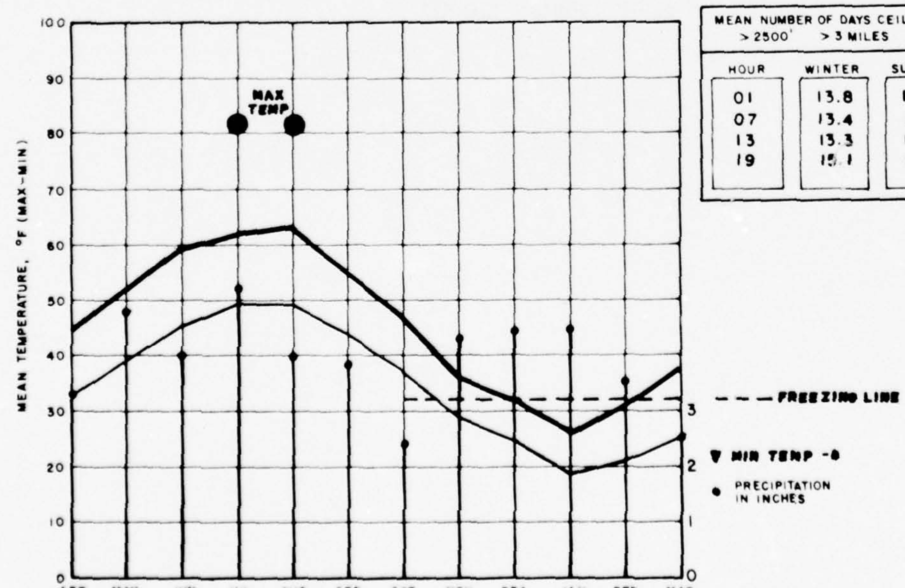
This tabulation, constructed from a co-mingling of arbitrary qualifiers and weather data, tends to show that German terrain will support ground operations the first day of any of the aforementioned frontal moves, summer or winter. Succeeding and longer frontal moves lead to greater exposure to terrain/weather influences and to air attacks, particularly in the summer season.

The tabulation also indicates that the function of air power in target selection, reconnaissance, and concerted attack are most seriously affected in the winter season. This is a consequence of the dominating character of German weather, persistent low cloudiness. Its principal attributes for military application are those of protective shielding from air attack and masking of ground strength and plans. Since this facet of weather is of lesser significance directly on ground operation a choice of the winter season for launching an attack favors the superior ground army. Air power is subtracted from both sides.

APPENDIX I

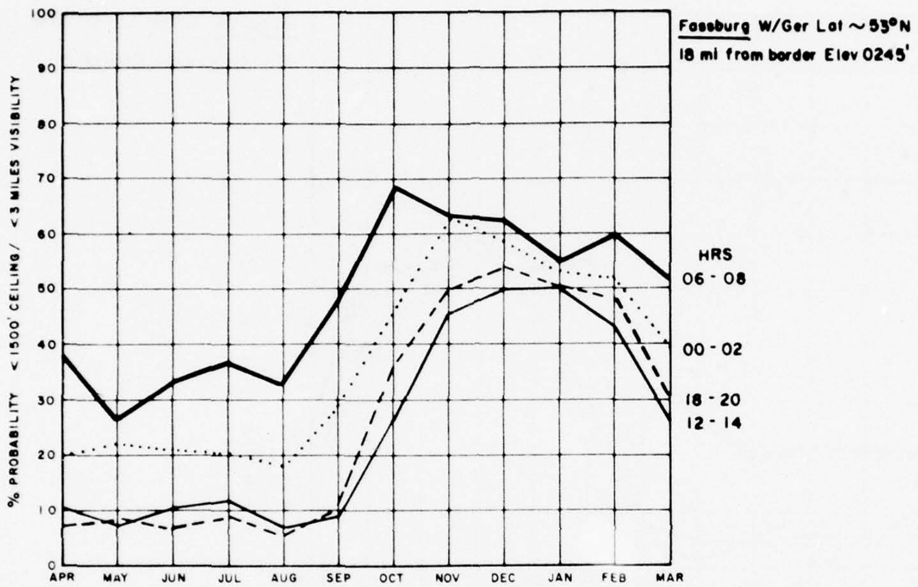
WEST GERMAN CHARTS



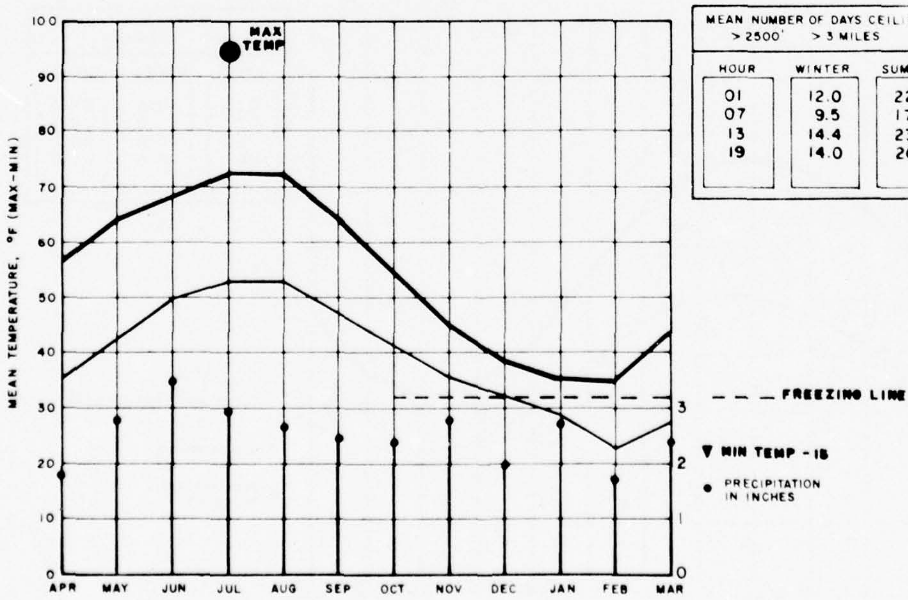


MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

HOUR	WINTER	SUMMER
01	13.8	17.9
07	13.4	17.4
13	13.3	12.1
19	15.1	19.9

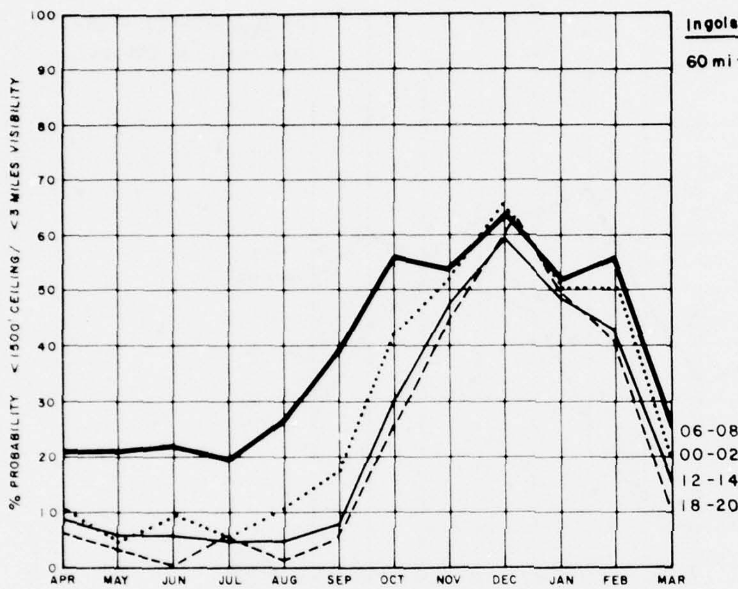


MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES		
HOUR	WINTER	SUMMER
01	12.0	22.3
07	9.5	17.5
13	14.4	23.1
19	14.0	26.1

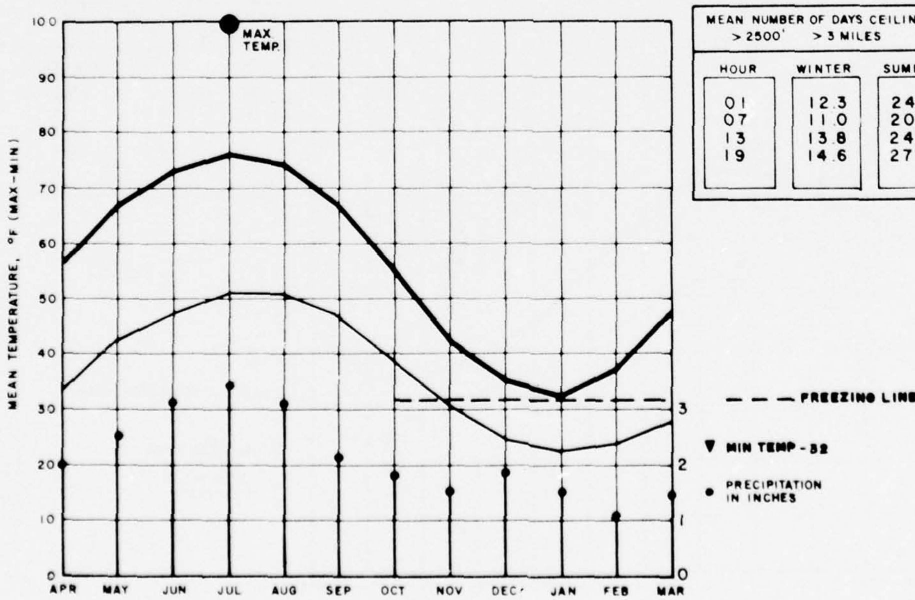


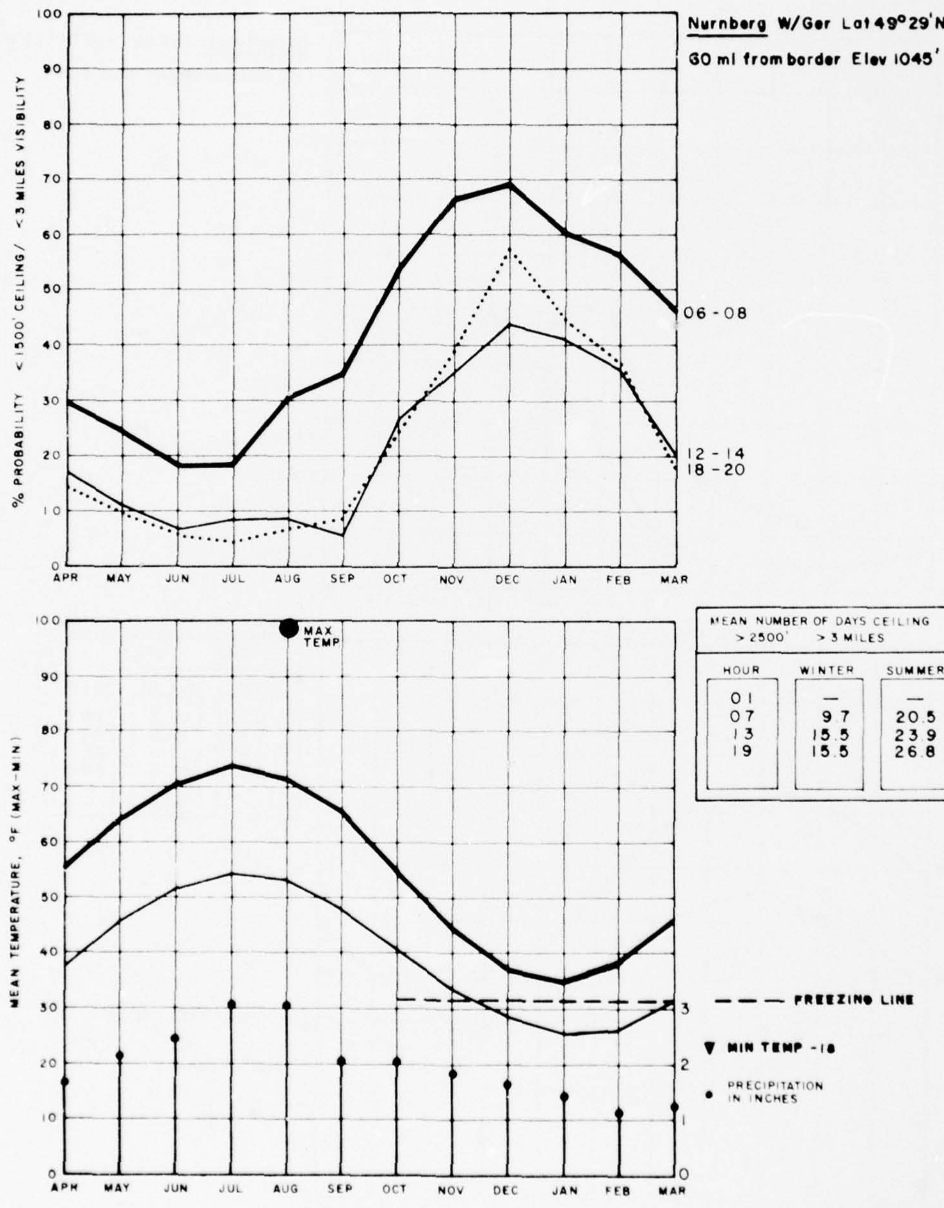
Ingolstadt W/Ger Lat 48°43'N

60 mi from border Elev 1214'



MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES		
HOUR	WINTER	SUMMER
01	12.3	24.3
07	11.0	20.2
13	13.8	24.0
19	14.6	27.0



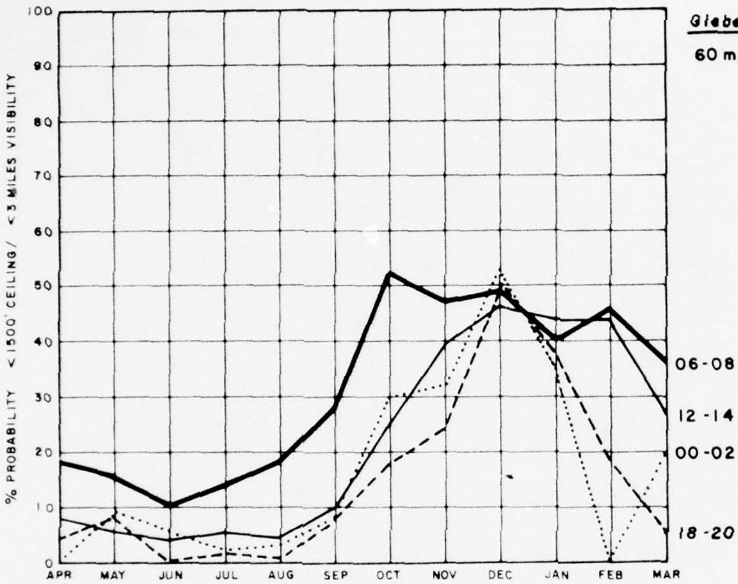


MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

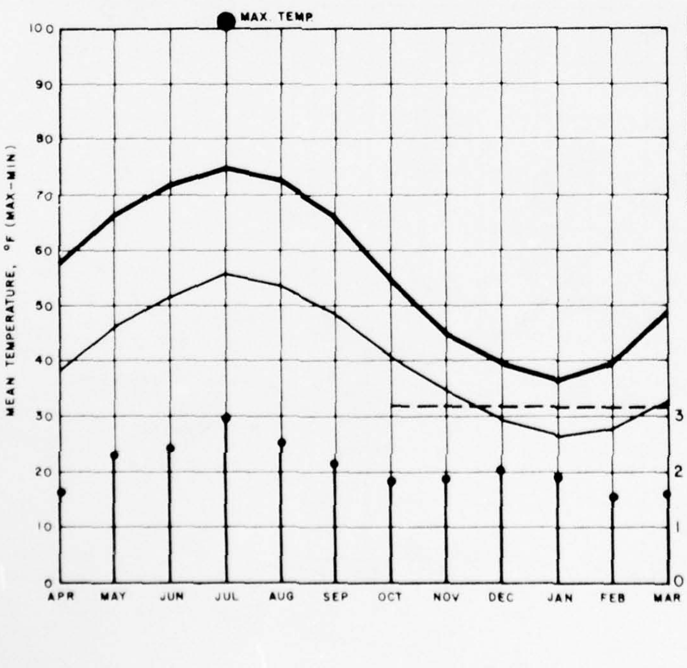
HOUR	WINTER	SUMMER
01	—	—
07	9.7	20.5
13	15.5	23.9
19	15.5	26.8

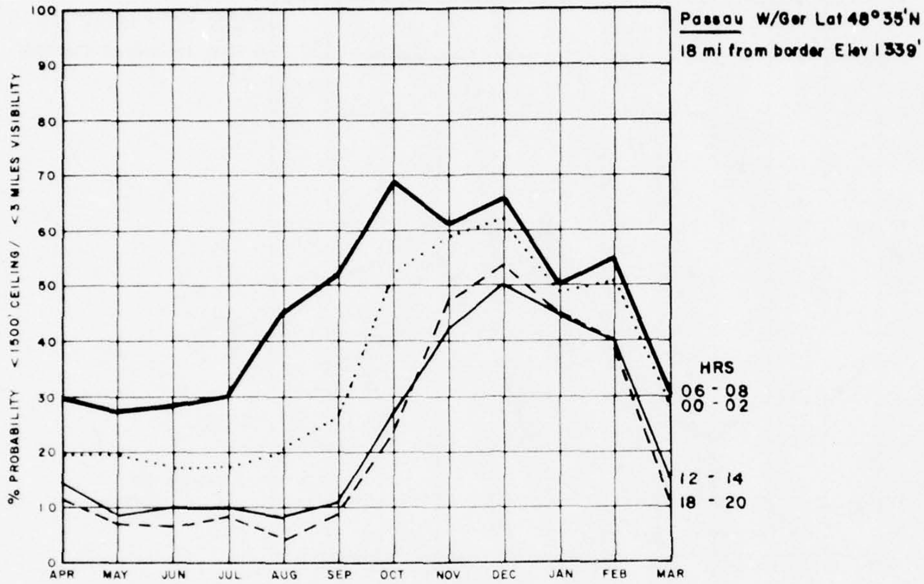
Giebelstadt W/Ger Lat 49°38'N

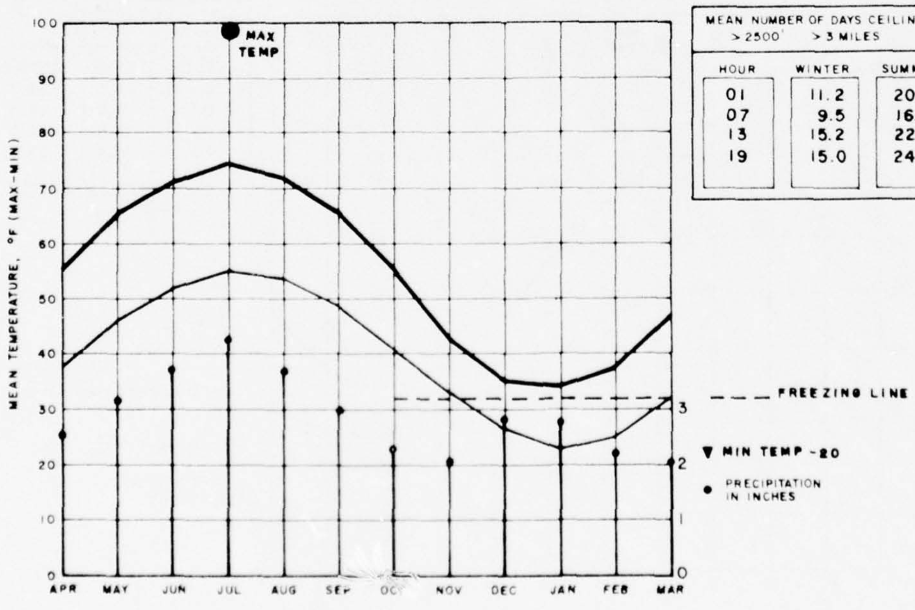
60 mi from border Elev 985'



MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES		
HOUR	WINTER	SUMMER
01	18.2	26.8
07	12.9	23.6
13	15.2	25.5
19	18.3	28.4

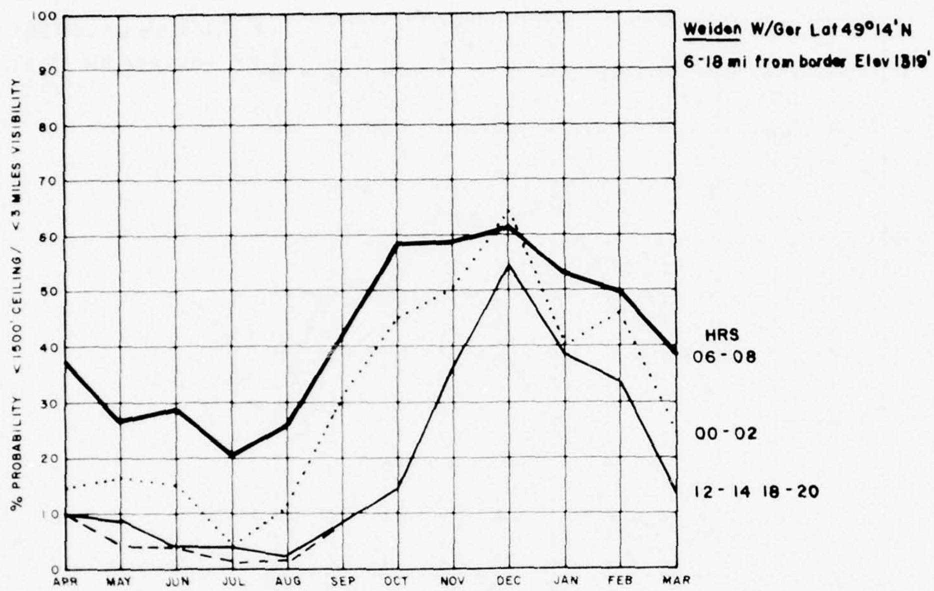


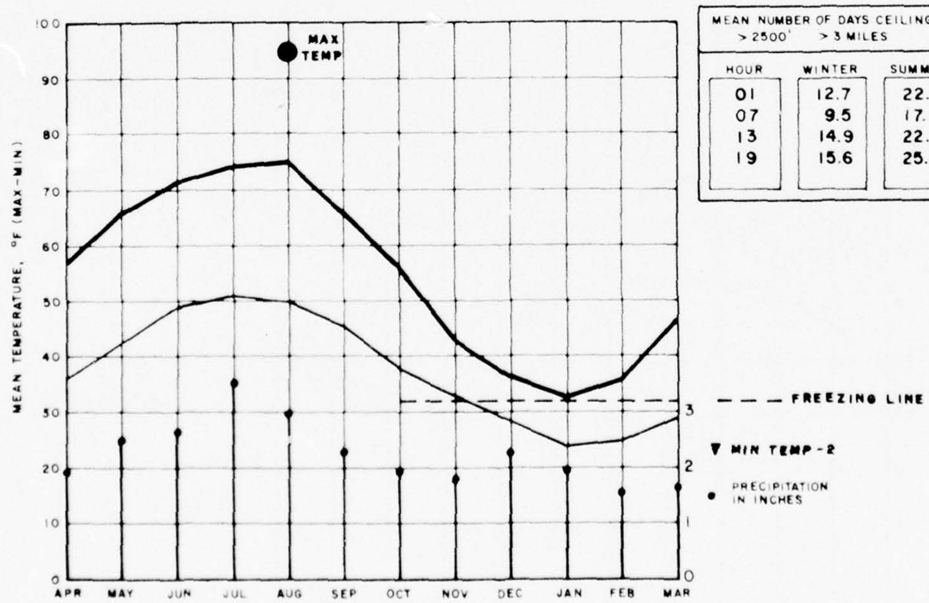




MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

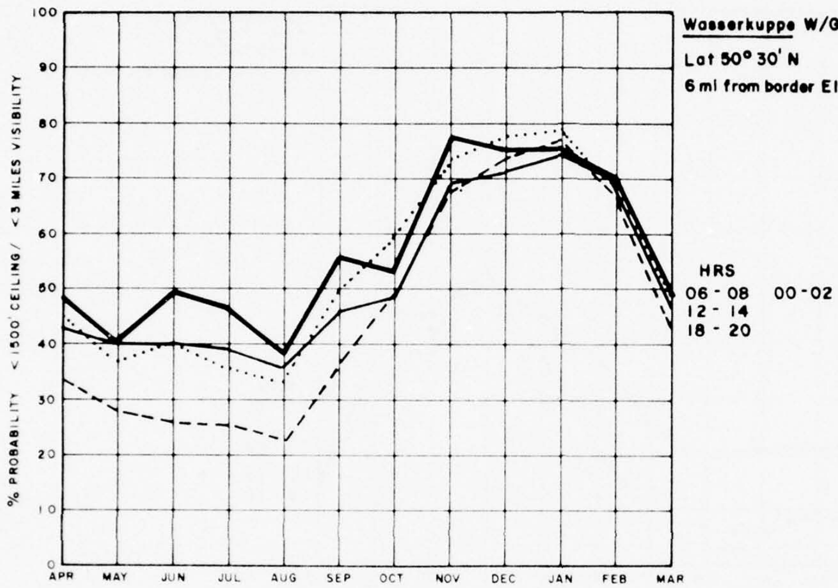
HOUR	WINTER	SUMMER
01	11.2	20.4
07	9.5	16.7
13	15.2	22.4
19	15.0	24.6



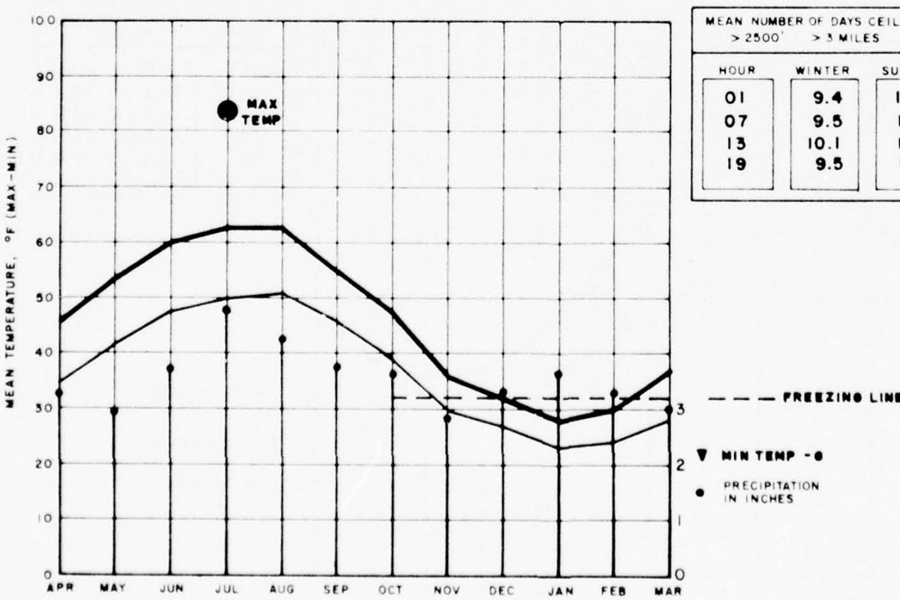


MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

HOUR	WINTER	SUMMER
01	12.7	22.7
07	9.5	17.8
13	14.9	22.5
19	15.6	25.6



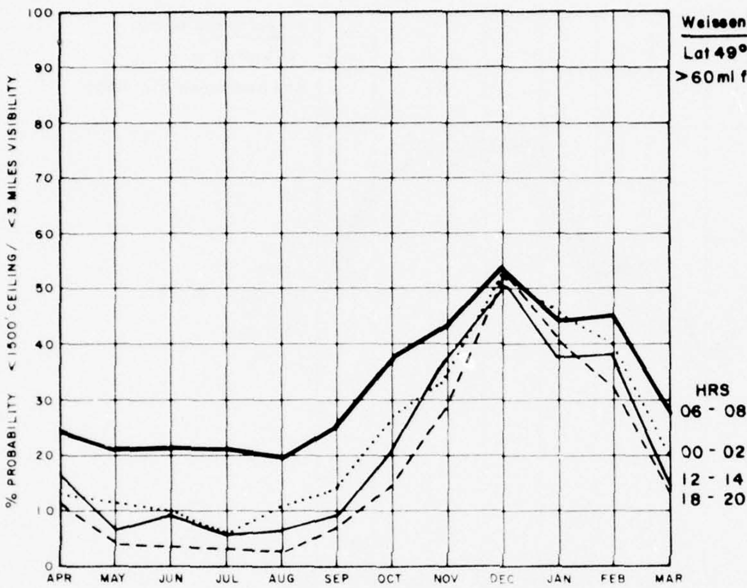
MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES		
HOUR	WINTER	SUMMER
01	9.4	16.6
07	9.5	15.3
13	10.1	14.6
19	9.5	19.7



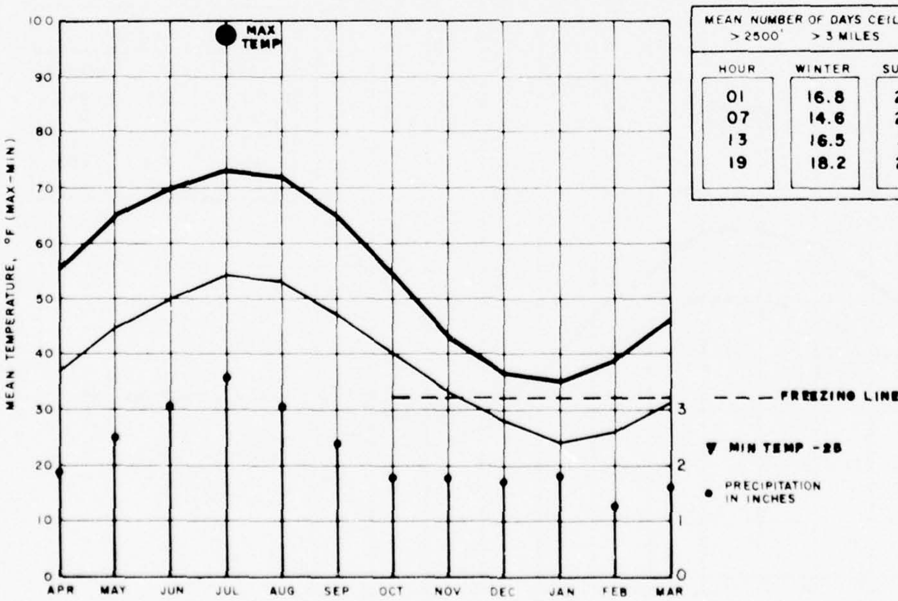
Weissenberg W/Ger

Lat 49°02'N

>60 mi from border Elev 1428'

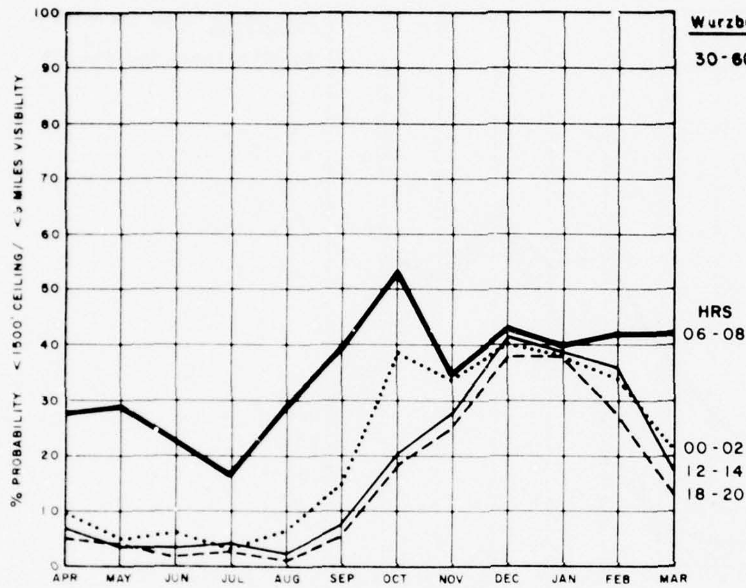


MEAN NUMBER OF DAYS CEILING >2500' >3 MILES		
HOUR	WINTER	SUMMER
01	16.8	25.8
07	14.6	22.0
13	16.5	19.5
19	18.2	27.4

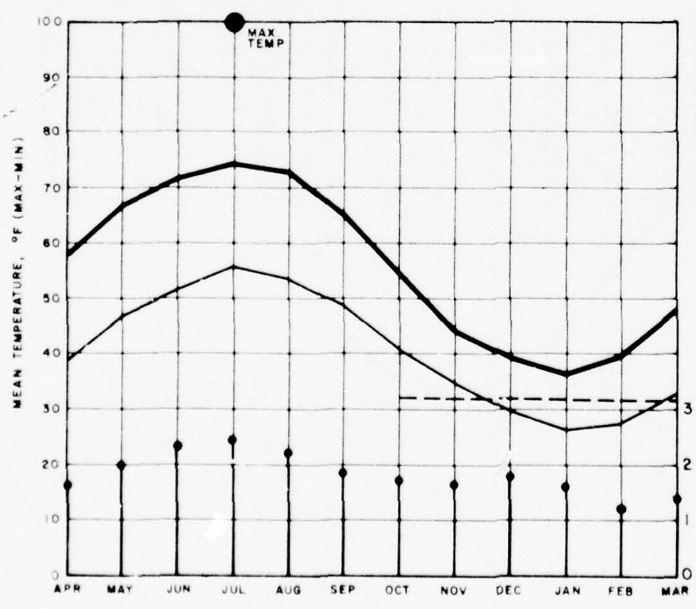


Wurzburg W/Ger Lat 49°48'N

30-60 mi from border Elev 8521'



MEAN NUMBER OF DAYS CEILING >2500' >3 MILES		
HOUR	WINTER	SUMMER
01	14.2	23.4
07	11.6	19.1
13	15.0	23.6
19	16.0	26.3



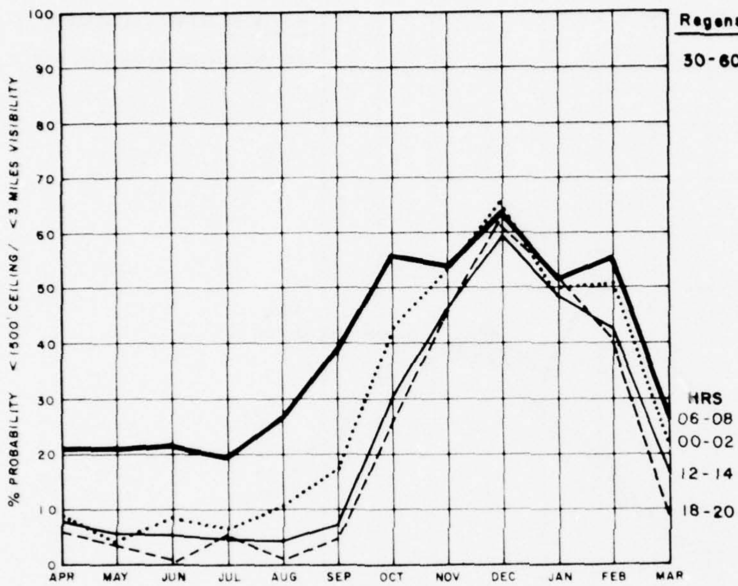
--- FREEZING LINE

▼ MIN TEMP -10

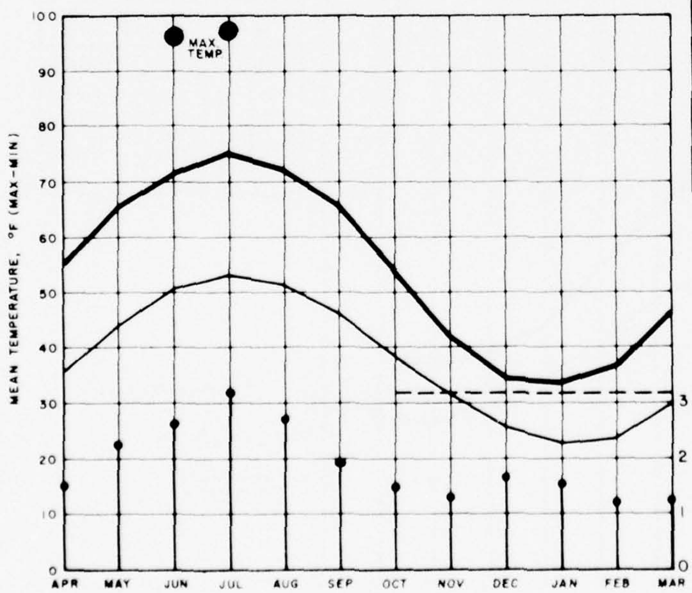
● PRECIPITATION IN INCHES

Regensberg W/Ger Lat 49°02'N

30-60 mi from border Elev 1113'



MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES		
HOUR	WINTER	SUMMER
01	12.2	24.2
07	10.9	20.2
13	12.1	24.0
19	14.3	27.1



— — — FREEZING LINE

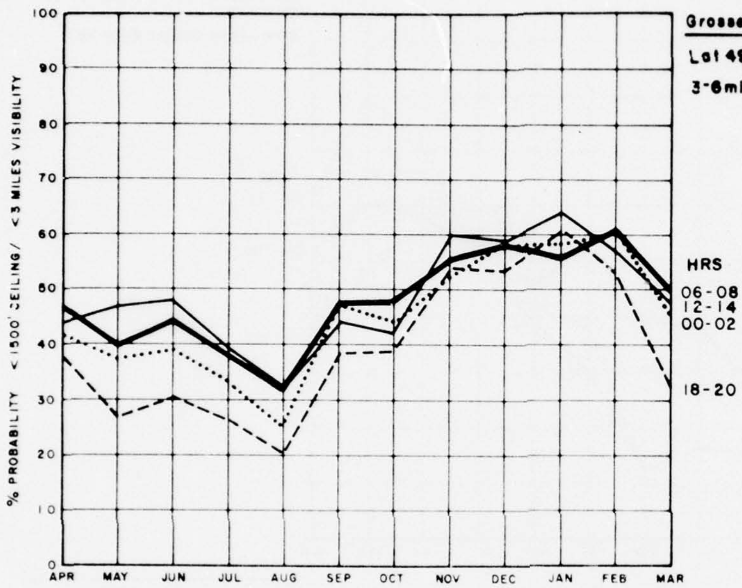
▼ MIN TEMP -20

• PRECIPITATION IN INCHES

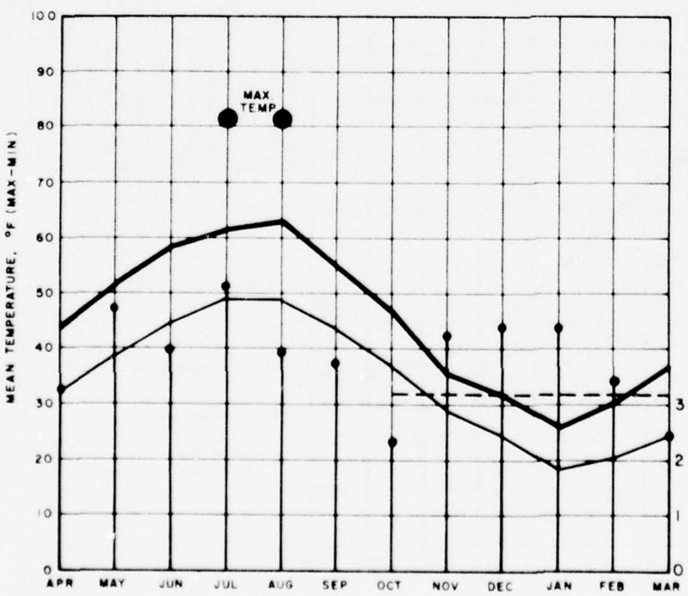
Grosser Falkenstein W/Ger

Lat 49°05'N

3-6 mi from border Elev 4291'



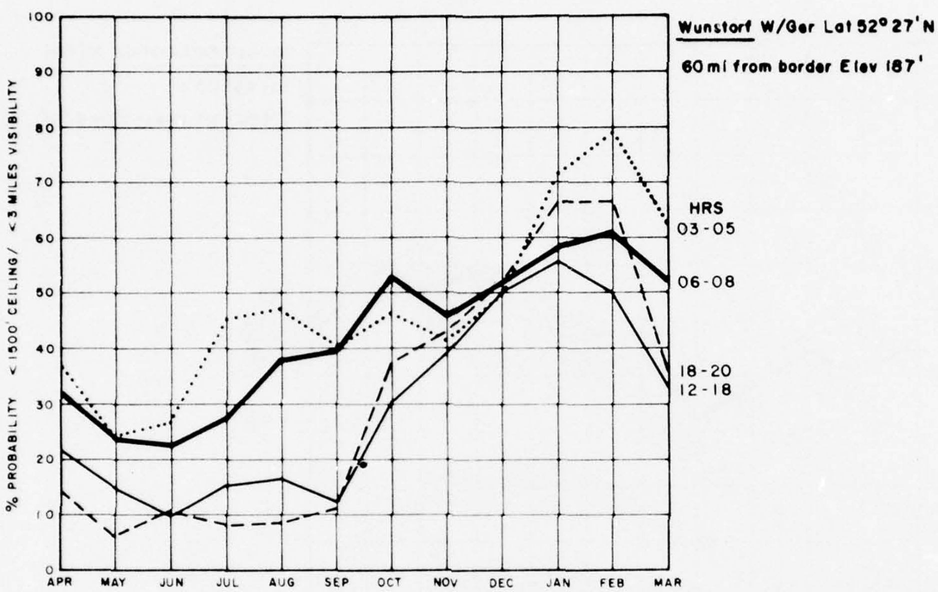
MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES		
HOUR	WINTER	SUMMER
01	13.8	17.9
07	13.4	17.4
13	13.3	12.1
19	15.1	19.9



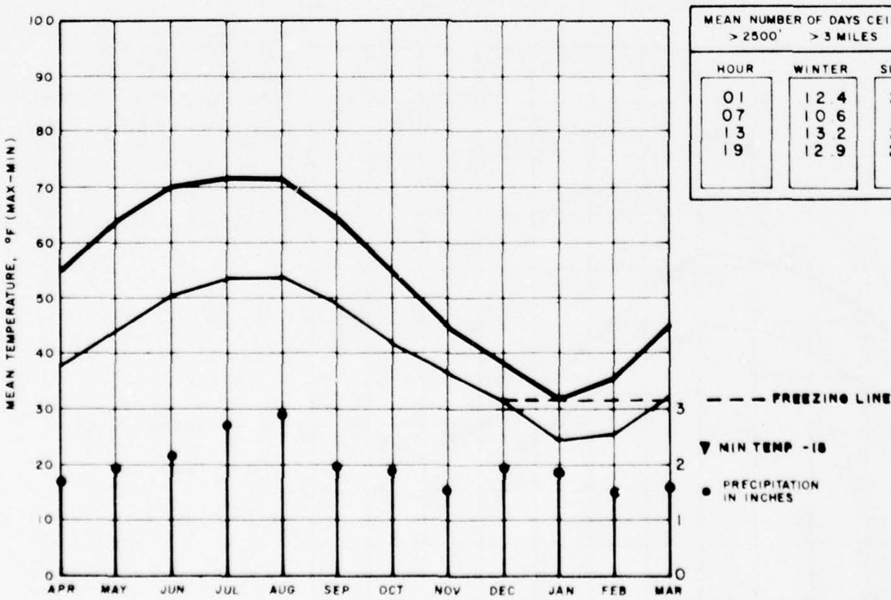
--- FREEZING LINE

▼ MIN TEMP -0 -0

● PRECIPITATION IN INCHES

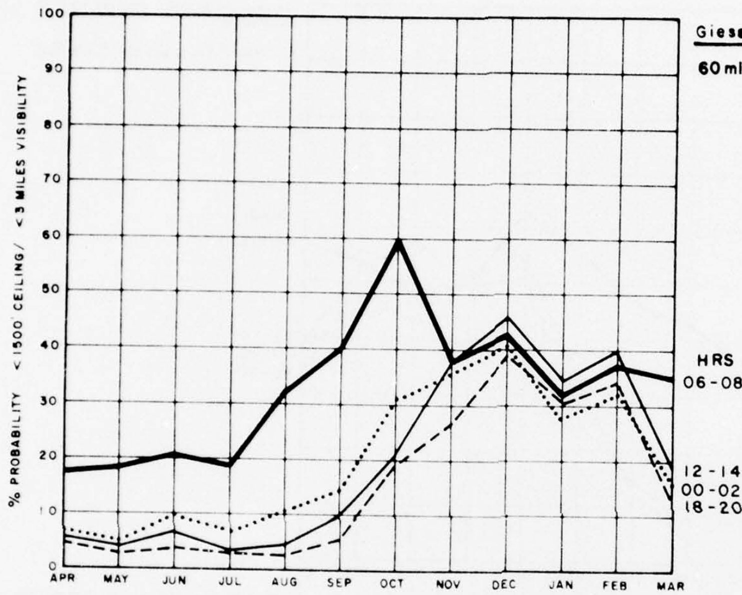


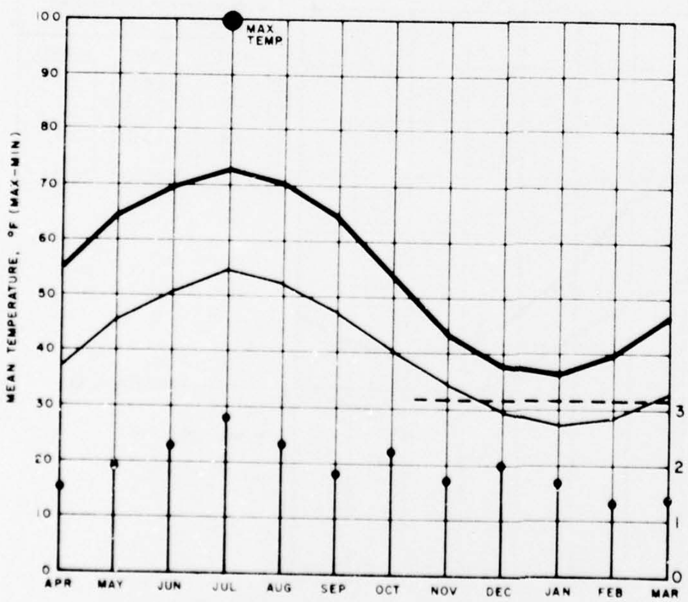
MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES		
HOUR	WINTER	SUMMER
01	12.4	25
07	10.6	18.5
13	13.2	20.3
19	12.9	24.2



Giessen W/Ger Lat 50°36'N

60 mi from border Elev 500'



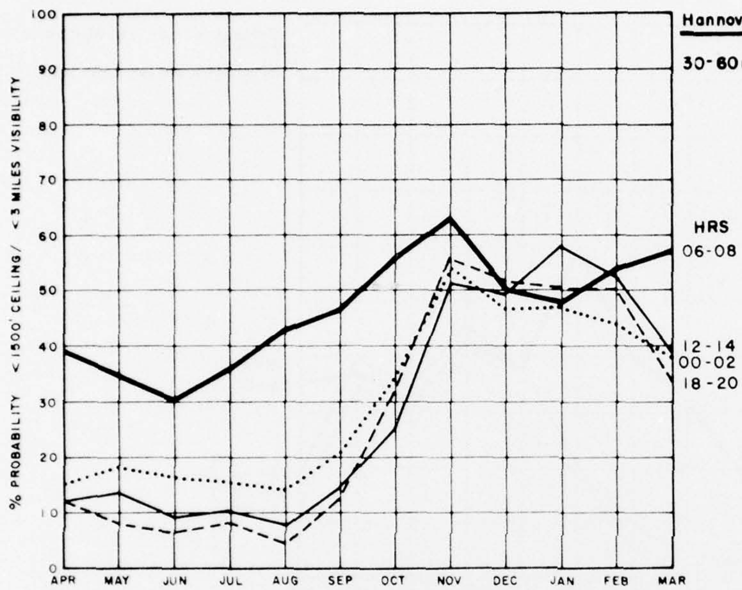


MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

HOUR	WINTER	SUMMER
01	14.7	23.4
07	11.0	18.6
13	13.7	22.3
19	15.3	24.5

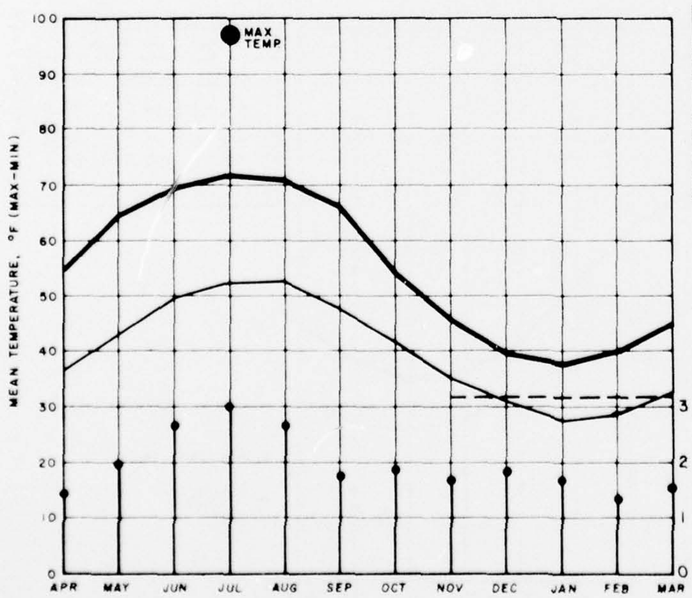
Hannover W/Ger Lat 52°27'N

30-60 mi from border Elev 180'



MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

HOUR	WINTER	SUMMER
01	14.1	23.6
07	11.3	17.1
13	14.0	23.5
19	13.7	25.7



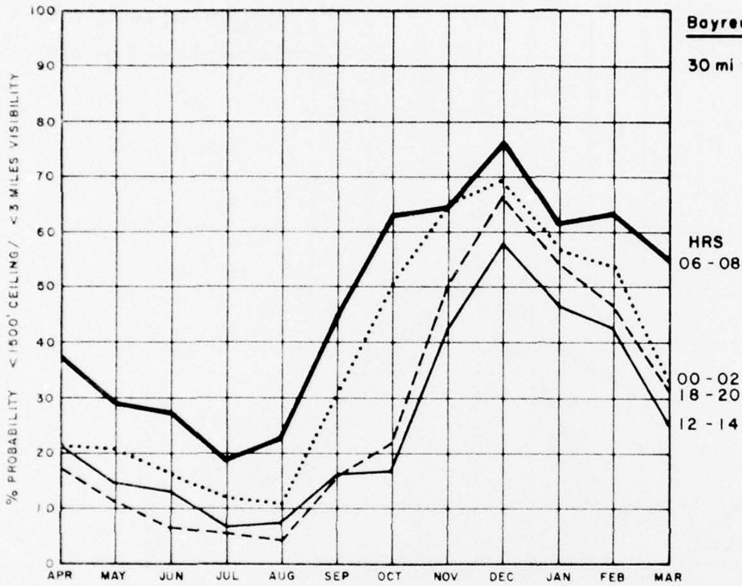
— — — FREEZING LINE

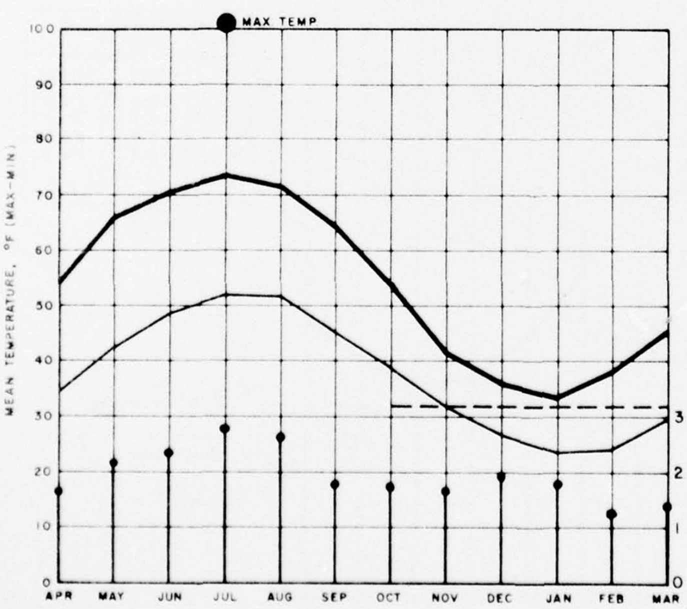
▼ MIN TEMP -13

• PRECIPITATION IN INCHES

Bayreuth W/Ger Lat 49°58'N

30 mi from border Elev 1186'



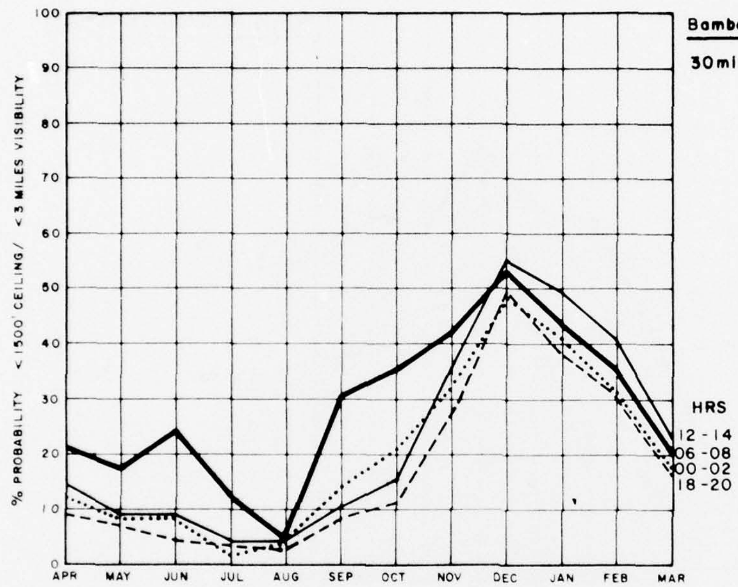


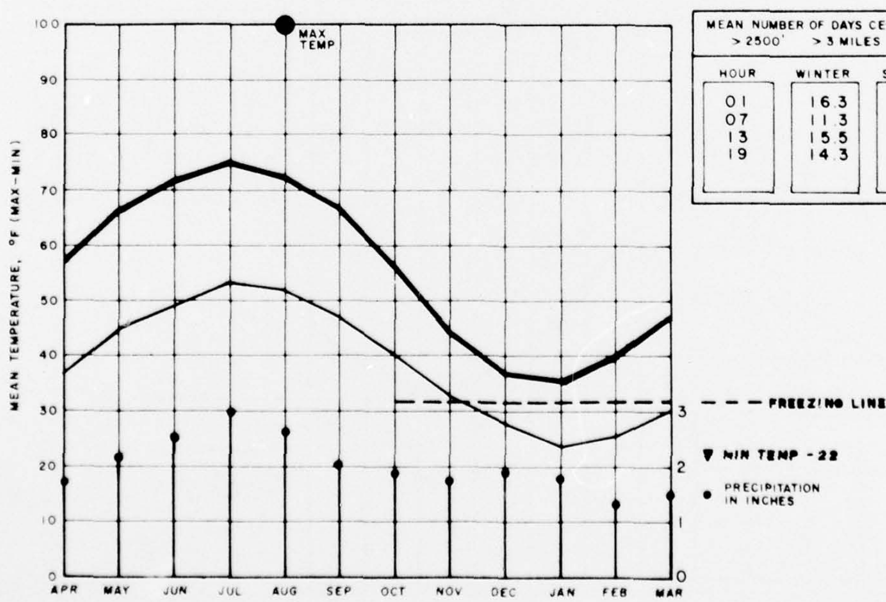
MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

HOUR	WINTER	SUMMER
01	9.8	21.1
07	6.9	17.3
13	13.2	20.6
19	12.6	26.6

Bamberg W/Ger Lat 49°53'N

30 mi from border Elev 1266'



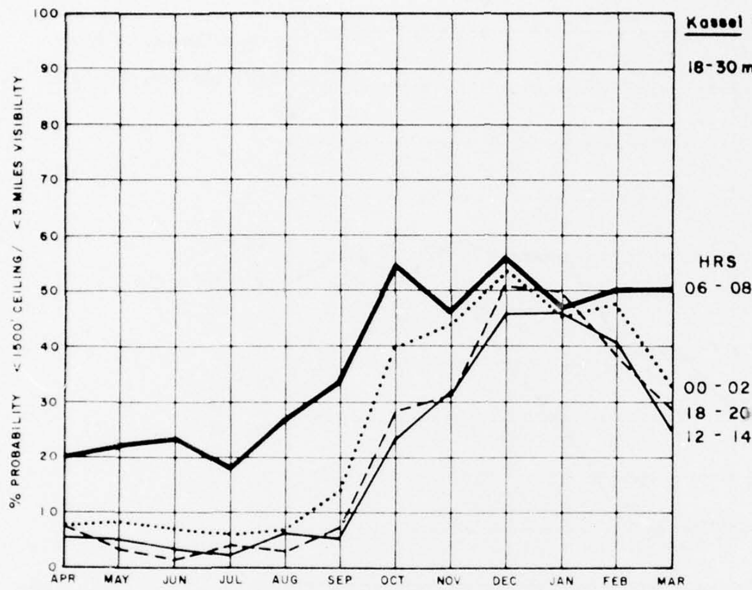


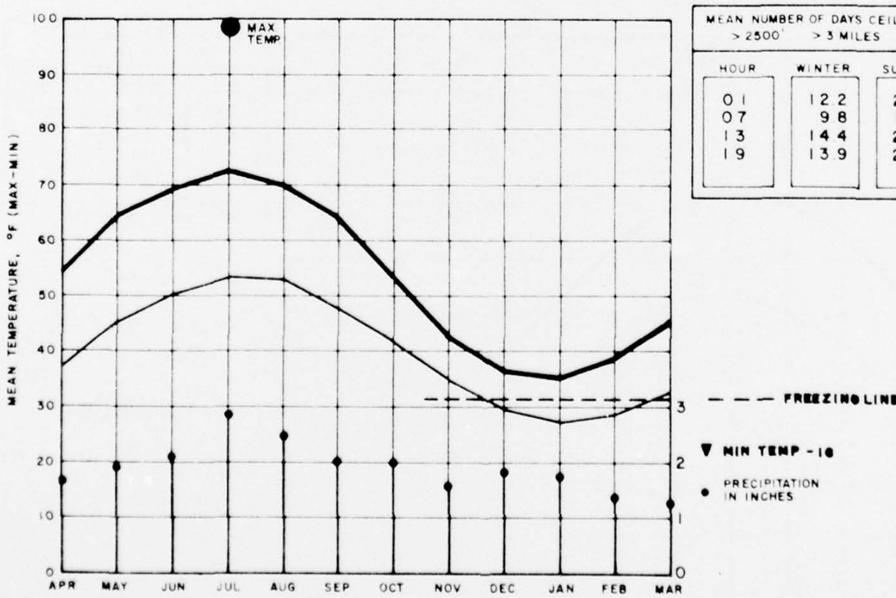
MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

HOUR	WINTER	SUMMER
01	16.3	25.2
07	11.3	22.5
13	15.5	23.7
19	14.3	26.3

Kassel W/Ger Lat 51°19'N

18-30 mi from border Elev 646'



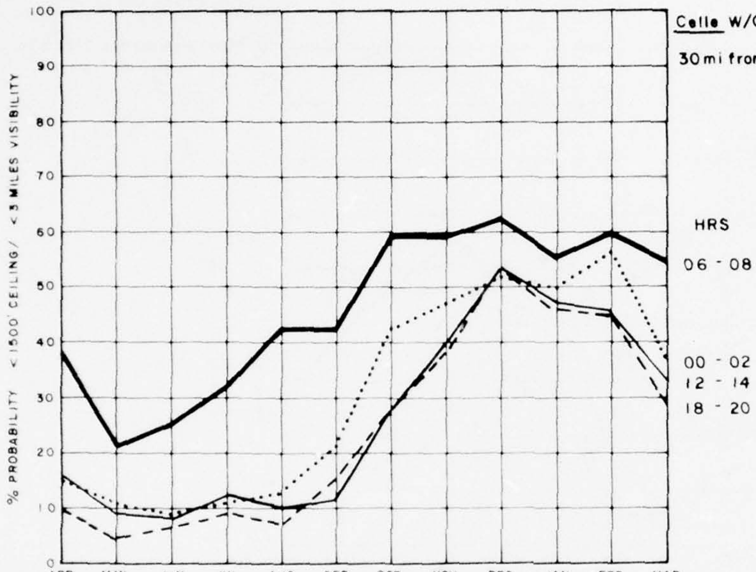


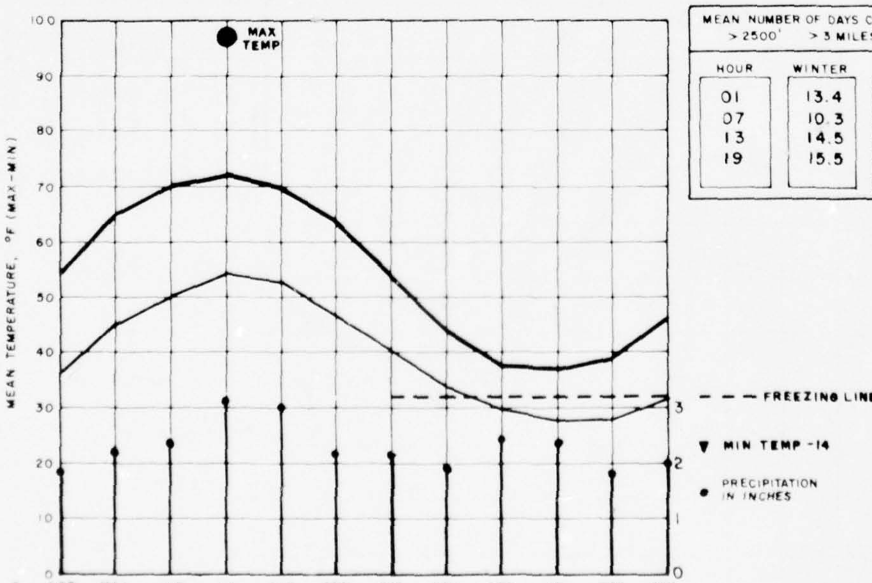
MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

HOUR	WINTER	SUMMER
01	12.2	26.1
07	9.8	19.6
13	14.4	26.1
19	13.9	26.3

Celle W/Ger Lat 52° 35'N

30 mi from border Elev 129'



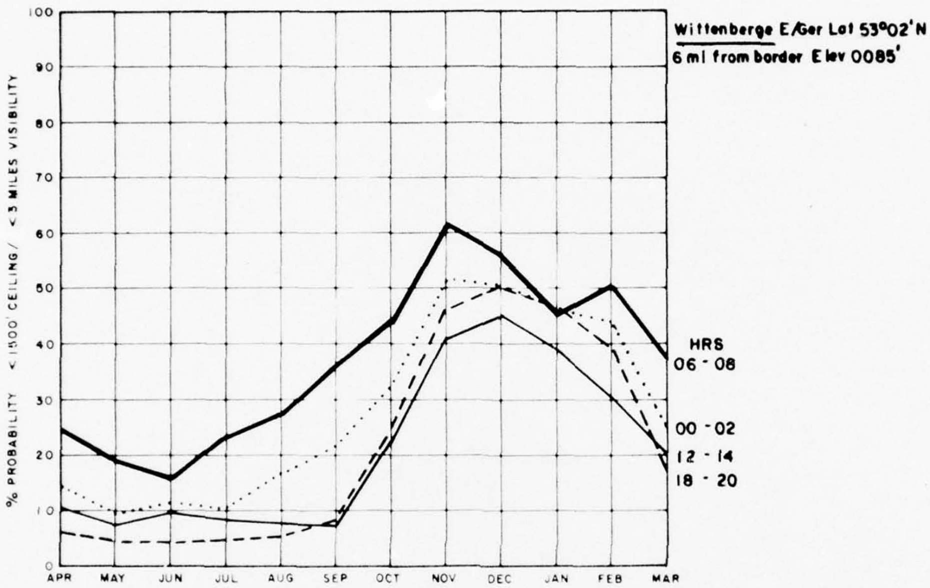


MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

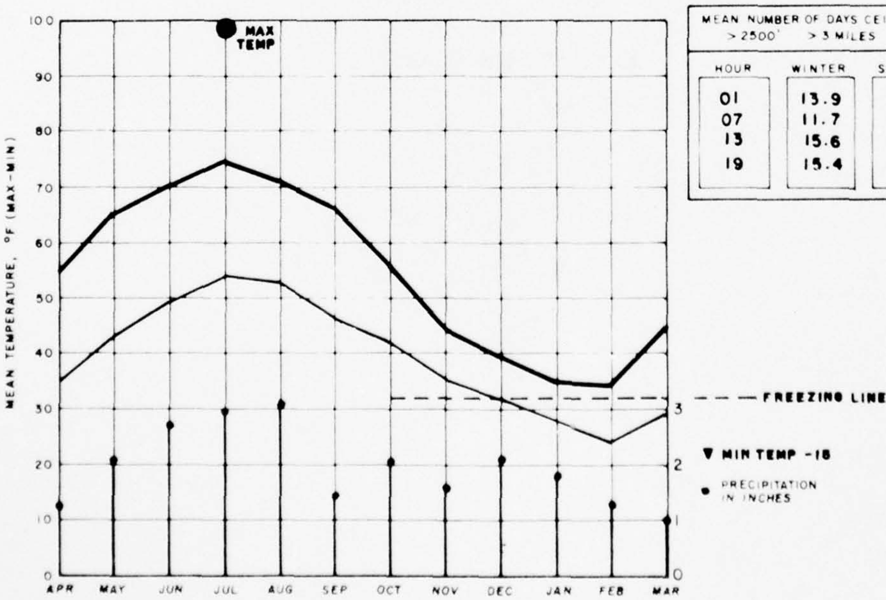
HOUR	WINTER	SUMMER
01	13.4	23.9
07	10.3	18.8
13	14.5	22.6
19	15.5	25.8

APPENDIX II

EAST GERMAN CHARTS

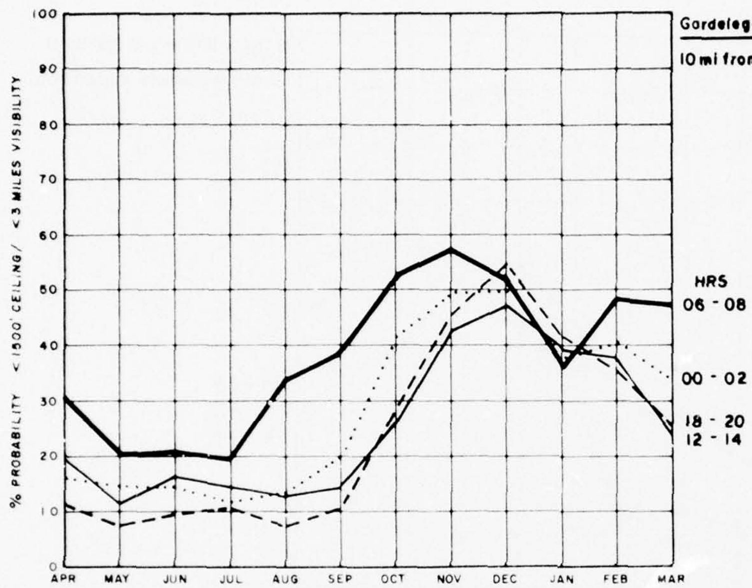


MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES		
HOUR	WINTER	SUMMER
01	13.9	23.5
07	11.7	20.1
13	15.6	23.5
19	15.4	26.4

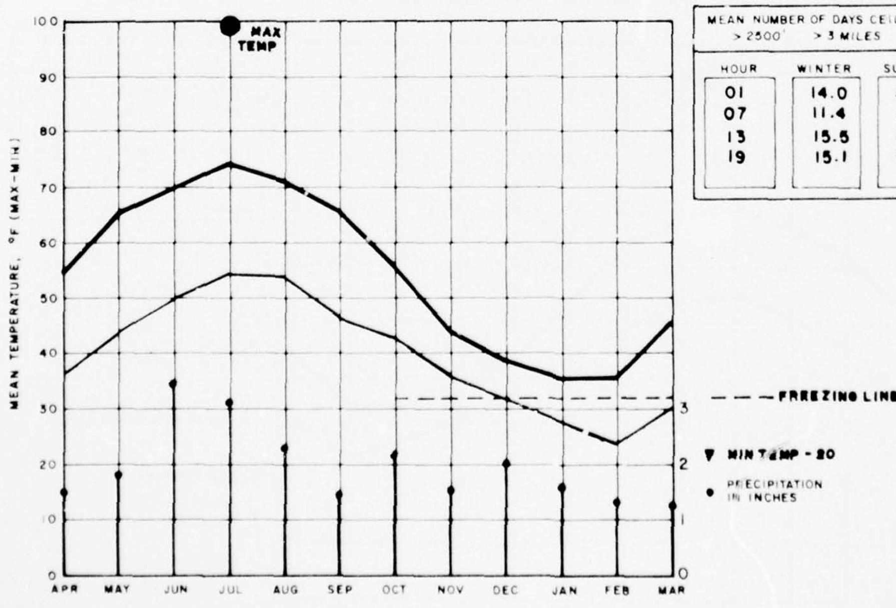


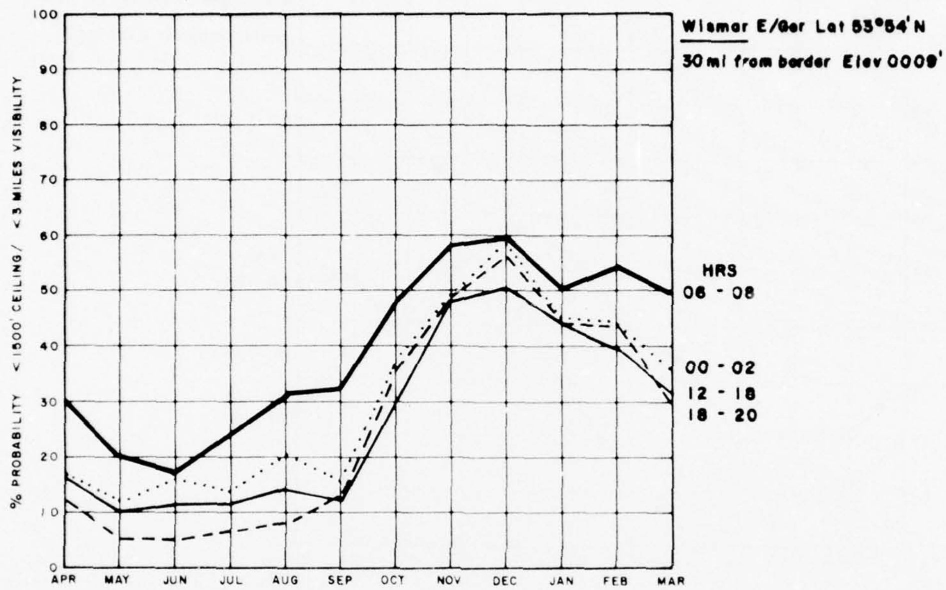
Gardelegen E/Ger Lat 52°31'N

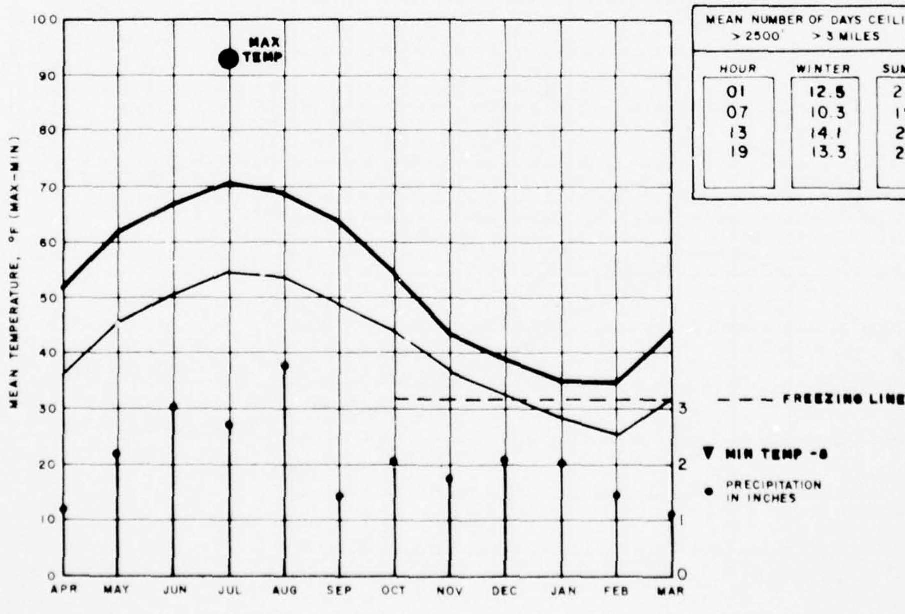
10 mi from border Elev 0157'



MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES		
HOUR	WINTER	SUMMER
01	14.0	22.7
07	11.4	18.7
13	15.5	21.1
19	15.1	24.4



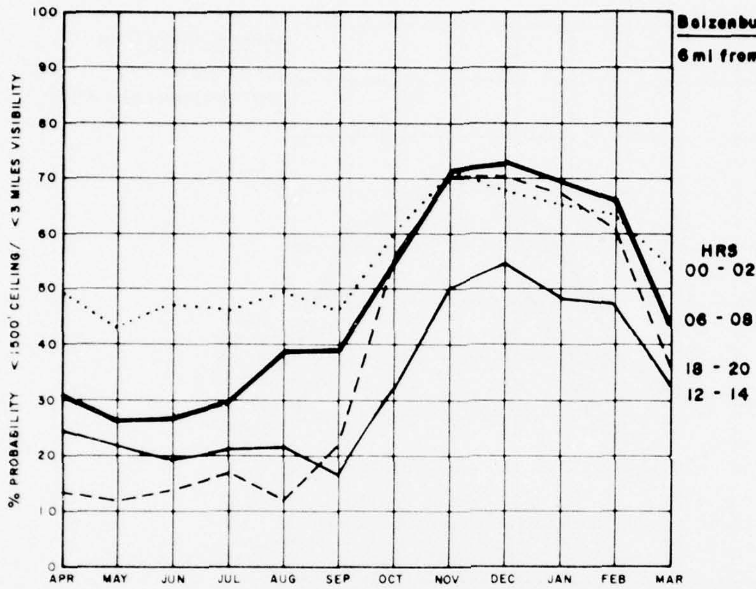




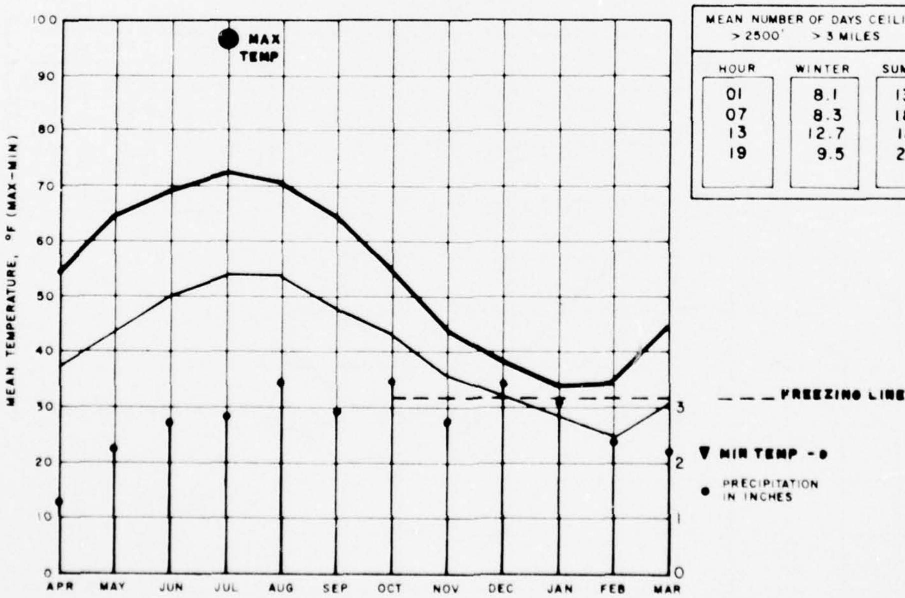
MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

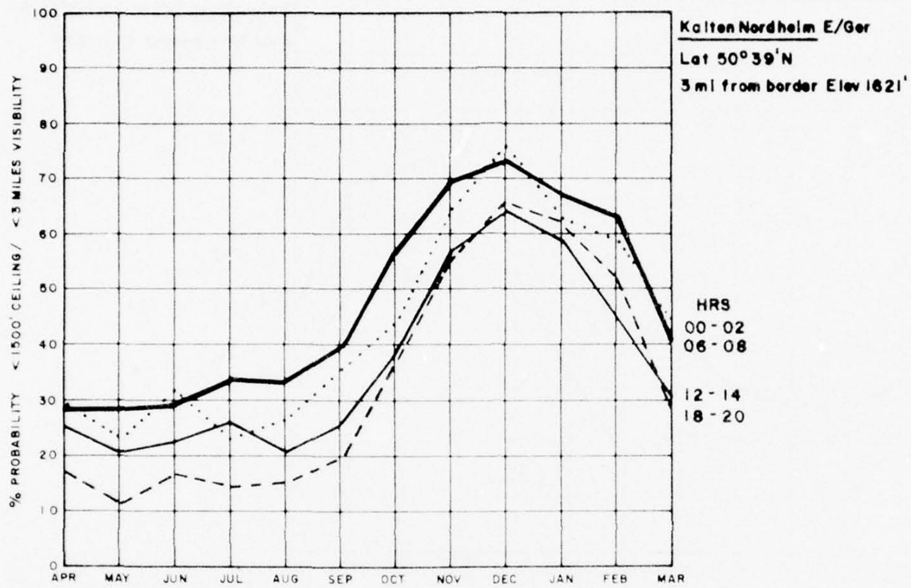
HOUR	WINTER	SUMMER
01	12.5	22.4
07	10.3	19.5
13	14.1	22.0
19	13.3	25.3

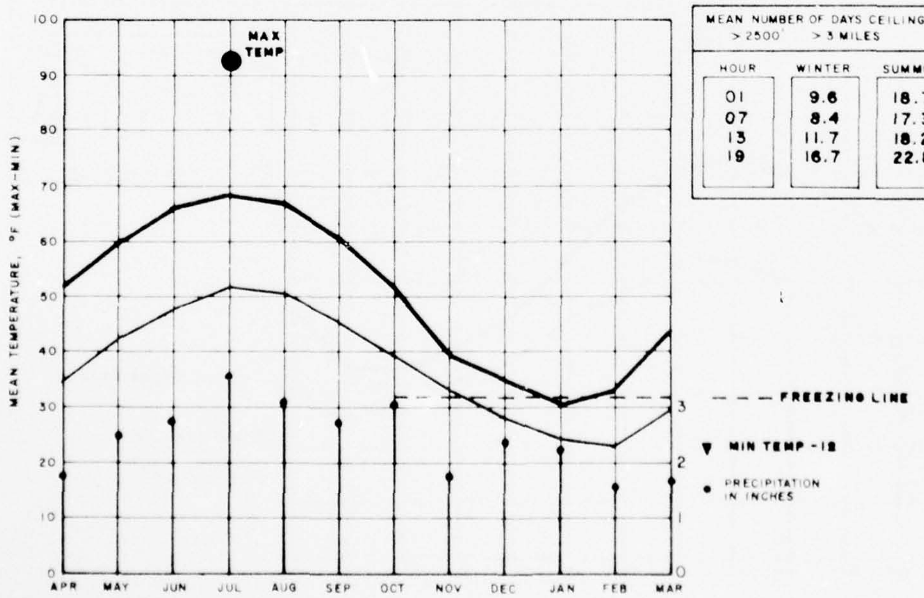
Boizenburg E/Ger Lat 53°23'N
6 mi from border Elev 0151'



MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES		
HOUR	WINTER	SUMMER
01	8.1	13.6
07	8.3	18.0
13	12.7	18.5
19	9.5	22.8

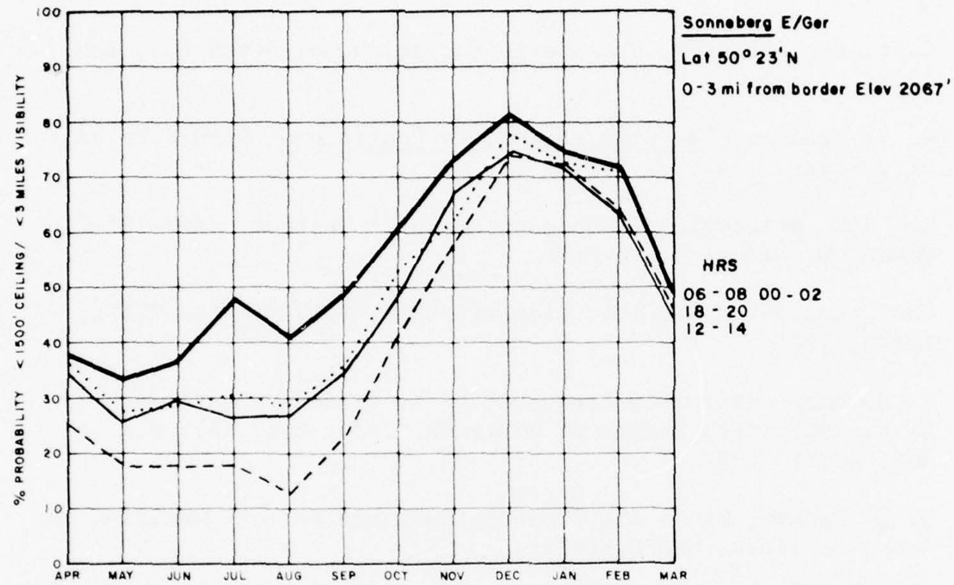


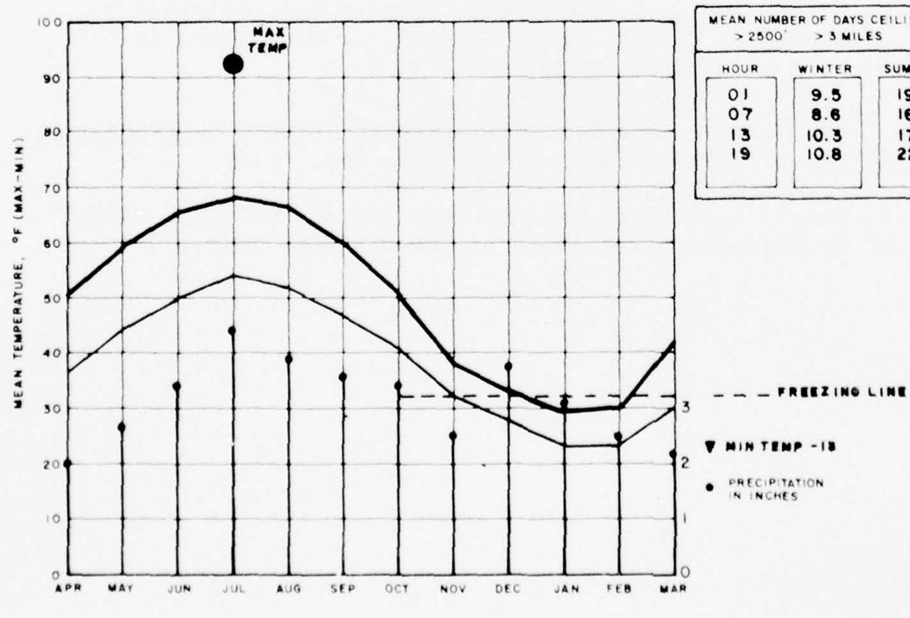




MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

HOUR	WINTER	SUMMER
01	9.6	18.7
07	8.4	17.3
13	11.7	18.2
19	16.7	22.8





MEAN NUMBER OF DAYS CEILING > 2500' > 3 MILES

HOUR	WINTER	SUMMER
01	9.5	19.1
07	8.6	16.8
13	10.3	17.6
19	10.8	22.7

REFERENCES

1. Capt. Butcher, USN, Crusade in Europe, Doubleday & Co., Inc., 1948, p. 345.

2. W. G. Kendrew, The Climates of the Continents, Oxford University Press, 1942, p. 235.

3. Hq. SAC, Strategic Air Command Manual - Weather, SACM-105-7, Omaha, Nebraska, Feb., 1972.

4. USAF, Worldwide Airfield Climatic Data, Vol. X & XI, ETAC, April, 1971.

5. I. Solomon, Estimated Frequency of Specified Cloud Amounts Within Specified Ranges of Altitude, Tech. Rpt. 167, USAF, AWS, April, 1957.

6. U. S. Senate, Close Air Support, Hearings before Committee on Armed Services, USGPO, 1972.

7. D. B. Carter and C. E. Molineux, "Average Soil Moisture and Tractionability Conditions in Poland", A. F. Surveys in Geophysics, No. 94, Aug., 1958.

8. WES Tech. Memo No. 3-240, "Soil Classification", TRAFFICABILITY OF SOILS, 16th Supplement, AD 265 743, Aug., 1961.

9. R. R. Rapp & C. Schutz, Calculations For A CLOUD-FREE-LINE-OF-SIGHT in Selected Climatic Zones, WN-7536-PR, July, 1971.